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AIR DEPLOYED OCEANOGRAPHIC MOORING (ADOM).(U)
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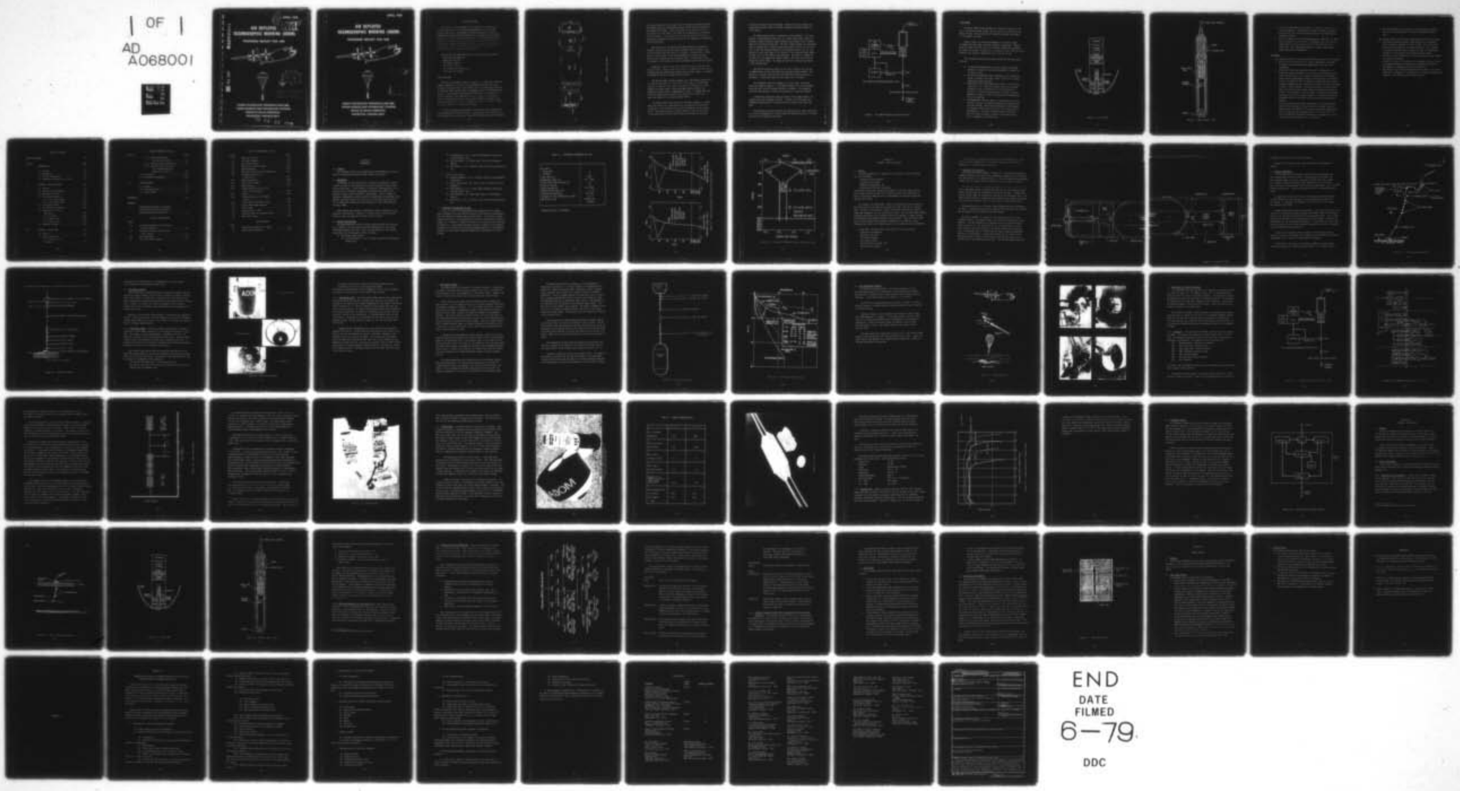

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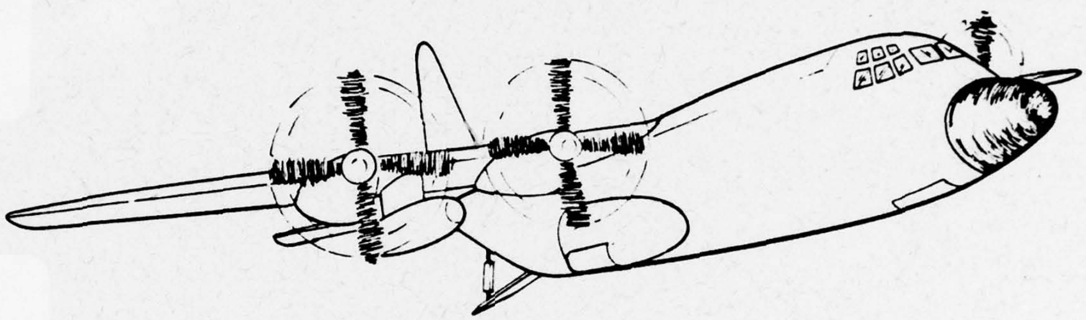
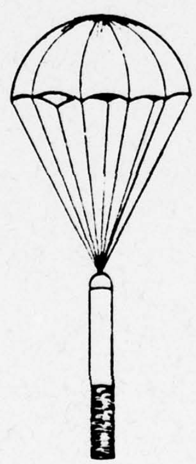
AIR DEPLOYED OCEANOGRAPHIC MOORING (ADOM)

PROGRESS REPORT FOR 1978





OCEAN TECHNOLOGY PROGRAM (CODE 485)
OCEAN SCIENCE AND TECHNOLOGY DIVISION
OFFICE OF NAVAL RESEARCH
ARLINGTON, VIRGINIA 22217

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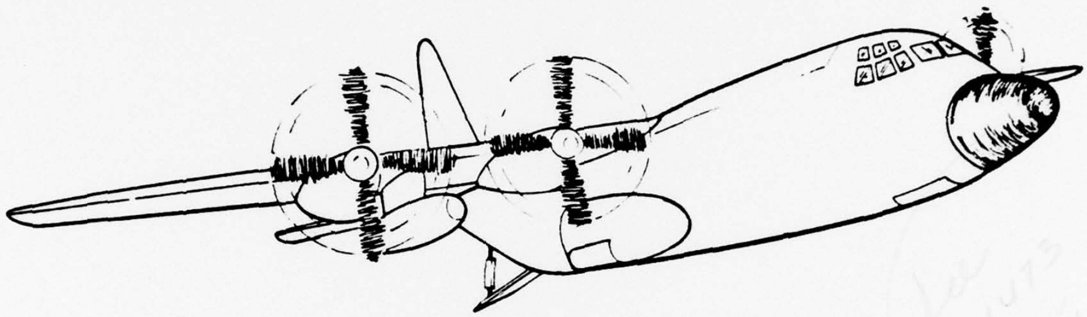

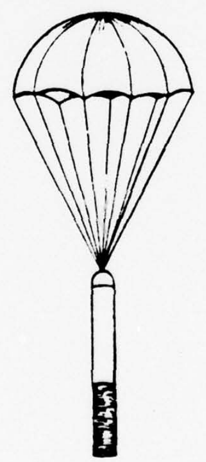

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EXECUTIVE SUMMARY

The purpose of this document is to present the technological accomplishments in the Air Deployed Oceanographic Mooring (ADOM) program during 1978. Technology is being developed for deploying oceanographic sensors from an aircraft in two regions of the world's oceans: the open ocean and the polar seas. Two corresponding systems are being developed: an open ocean ADOM and an Arctic ADOM. Both systems are presently configured to measure temperature, conductivity, and pressure. However, the systems have sufficient flexibility to allow the addition of other types of sensors.

During 1978, the ADOM concept was studied in six major areas:

- Structure and Packaging,
- Material Properties,
- The Anchor Assembly,
- The Surface Tether,
- The Decelerator Assembly, and
- Electronic and Sensor.

Open Ocean ADOM.

The open ocean ADOM is shown in Figure 1. It shows the parachute chamber attached to the end of the electronics canister that runs through the surface float. The surface float is a cylindrical annulus of syntactic foam, covered with a fiberglass jacket for additional protection. The telemetry electronics and batteries are contained in a pressure housing. The subsurface buoy is a hollow, rigid aluminum tank with hemispherical ends. The anchor assembly is coupled to the subsurface buoy by one of three separation collars. The anchor itself is a heavy wall cast ductile steel housing.

In 1978, samples were obtained of the mooring line components and their engineering properties tested. Stress-strain and ultimate tensile strength tests, as well as creep and torsional tests were conducted.

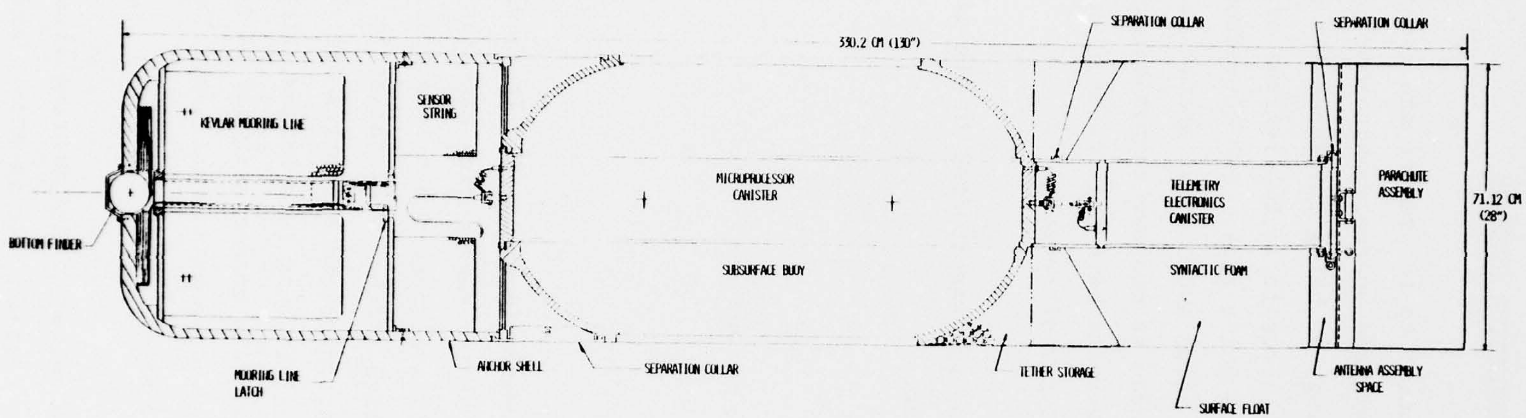

Figure 1. Open Ocean ADOM

The stress-strain and creep tests were of particular interest because the nominal depth of the subsurface buoy is less than two percent of the design water depth. Thus, elongation of the mooring line has a large effect on buoy depth. This must be accommodated by the bottom-finder mechanism. It was found that creep adds about 50 percent to the initial elongation during the first day of loading, but practically nothing thereafter.

Upon splash down, the open ocean ADOM releases the parachute assembly from one end and the anchor assembly from the other, leaving the coupled float and buoy on the surface. During 1978, a prototype full scale model of the anchor assembly was constructed and tested in the laboratory and in shallow water. During these tests, the design of the mooring line lockup mechanism was refined and proven.

Analysis of the in-water fall stability of the anchor was conducted in 1978. Tank and lake drop tests are planned in early 1979 to determine whether stabilizing devices such as fins, flaps, or a drogue are needed to assure a straight smooth descent.

The bottom finder concept consists of a lead weight connected to the mooring line latch by a wire rope. The impact of splash down shatters a frangible cover over the plumb bob, allowing it to fall beneath the anchor shell. When the weight touches bottom, the pendulum wire goes slack, triggering the latch. A trigger lock prevents the splash down transient from latching the mooring line until the anchor is at a depth of about 500 m.

The ADOM surface float supports a telemetry antenna. A tether moors the float to the subsurface buoy and conducts data from the processor in the subsurface buoy to the transmitter in the surface float. The tether allows the surface float to ride 10 foot waves in the operational current profile while protecting the delicate

electrical conductor from wave damage. When the current exceeds the operational profile speed, the tether submerges the surface float to a safe depth.

The ADOM buoyant tether is composed of three segments. Its basic element is approximately 300 meters of a small double armor cable containing a single insulated signal conductor and covered with a plastic jacket for corrosion protection. The 122 m length nearest the subsurface buoy is covered with a foamed polyethylene jacket so that its net buoyancy is half the immersed weight of an unjacketed cable; that is, the buoyancy of the foam jacket is 150 percent of the immersed cable weight. The next 122 m is not foamed, just jacketed. The cable is clamped to the end of a 15 m segment of elastic rubber, and then 53 m are coiled around the rubber thong. The thong and wire are joined and connected to the surface float.

The PCU-8/A parachute system is the prime candidate for use with the ADOM system in both under-wing and fuselage release methods. The PCU-8/A is currently used to lower the Navy CTU-2/A Aerial Delivery Container. It has been tested at air speeds up to 450 knots.

The components that are included in the electronic and sensor system are shown in Figure 2. The ADOM processor with its data memory and power pack form the central electronic assembly. The segmented cable has terminations to allow the insertion of calibrated sensors.

A laboratory simulation using 10 active and 90 dummy sensors (to simulate the cable loading) was made. A cable, with resistance and impedance characteristics to match the 1500 m sensor array cable was used.

Ten prototype sensors have been constructed and are under evaluation. They will be packaged into a 1500 m array and deployed as part of a drifting test in the Tongue-of-the-Ocean.

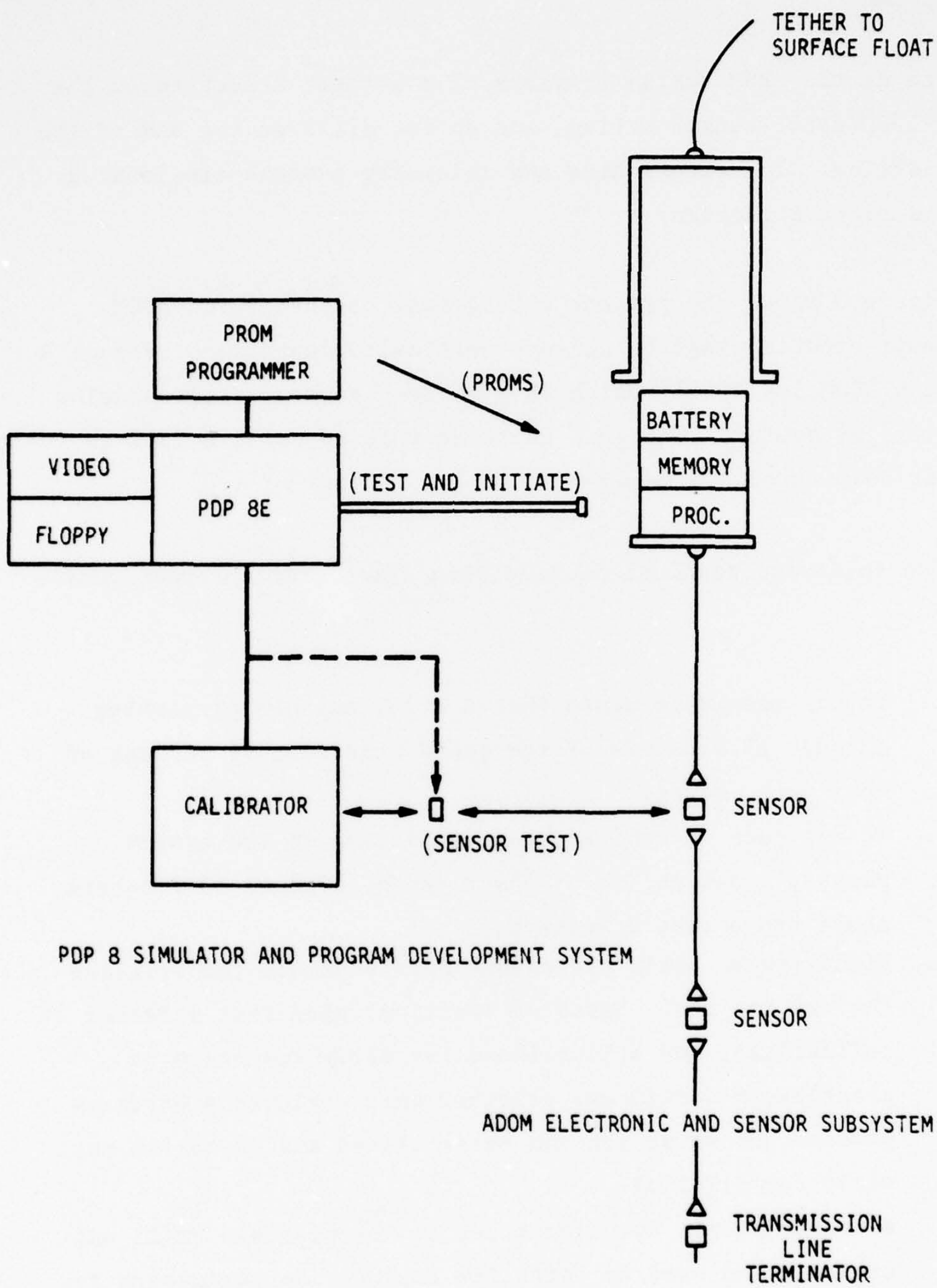

Figure 2. The ADOM Electronic and Sensor System

Arctic ADOM.

The Arctic ADOM system consists of a support structure on the ice, a 1500 meter sensor string, and an ice drill at the end of the sensor string. The electronics and telemetry systems are located in the support structure.

Figure 3 shows the present arrangement of the Arctic ADOM. It employs erection legs to achieve vertical orientation. Figure 4 shows the ADOM ice drill, which is a battery powered recirculating hot water jet system. The goal is to be able to drill a 15.2 cm (6 in.) diameter hole through a maximum of 15.2 m (50 ft) of ice.

The following conclusions have been drawn from the past year's efforts:

a. It has been determined that a drill capable of passing through 15.2 meters of ice would penetrate 99 percent of the Arctic cover.

b. It has been determined that, depending on the system employed, a design for a lesser depth, even to 10.7 meters, could prove cost effective.

c. Eighty-seven basic approaches were examined for drilling through the ice. Based on decision rules that stressed reliability, and a likelihood for early reduction to practice, a system was selected that employed a battery-powered hot water jet and recirculated and re-heated melt water for drilling.

d. A thermodynamic computer model of the proposed drill was created, and used to establish engineering parameters for the drill design. Resulting questions were raised about the thermal coefficients of the ice with a high velocity scrubbing jet. The model confirmed earlier estimates that 35-45 kWh of energy is likely to be required for a 15.2 cm diameter, 15.2 meter hole.

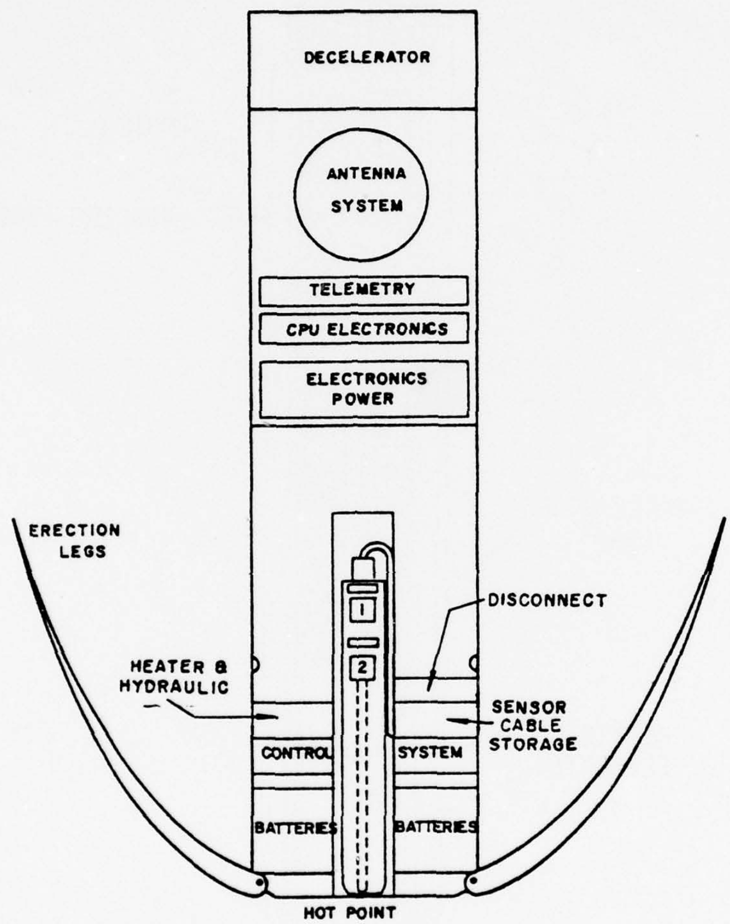

Figure 3. Arctic ADOM

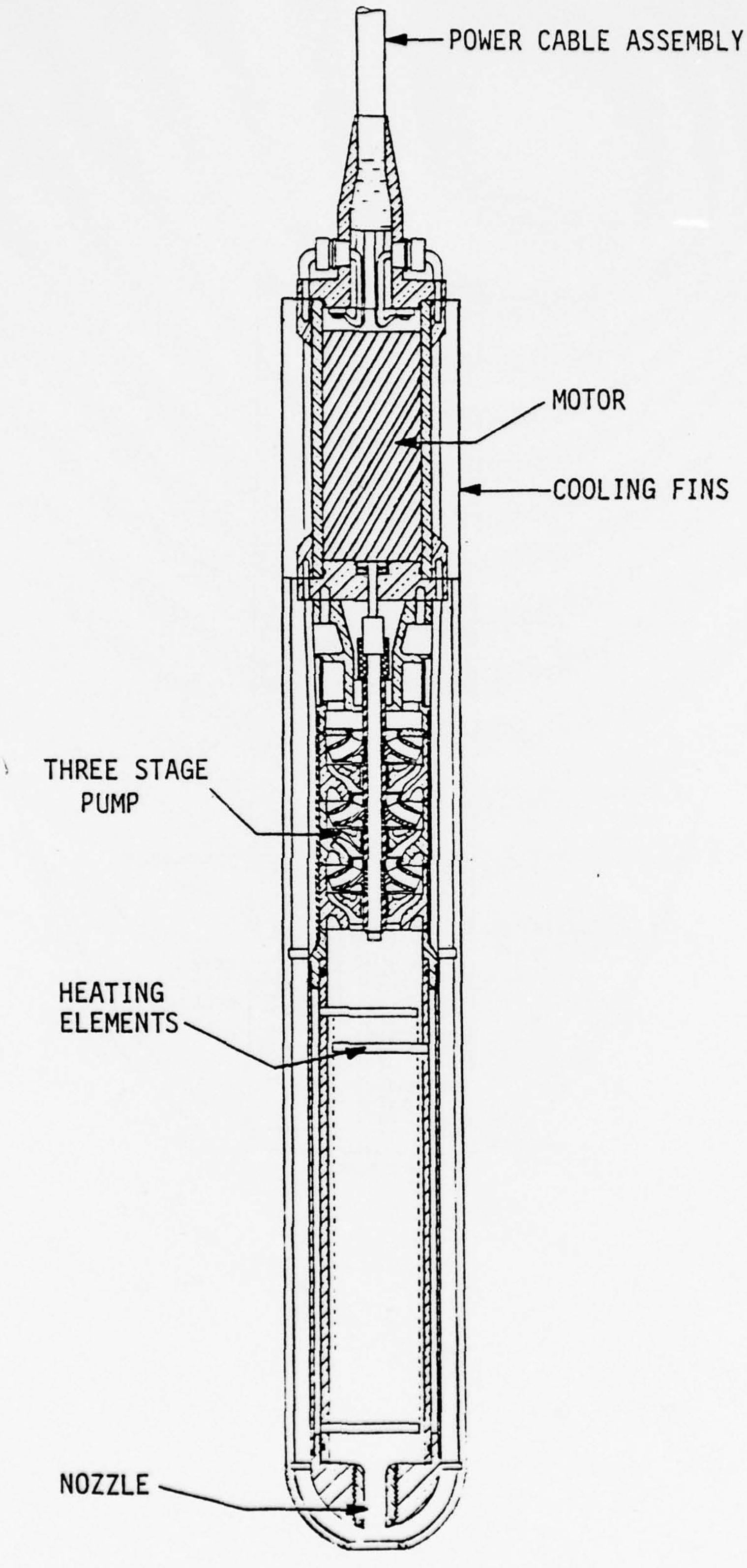

Figure 4. ADOM Ice Drill - CVM

e. A plan for experimentally determing the thermal coefficients of ice was generated. Experiments are being conducted in cooperation with the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL).

f. A first attempt at Arctic ADOM packaging was completed. It shows that a cylinder 53.3 cm (21 in.) in diameter, 335.3 cm (132 in.) long, weighing in the vicinity of 657.6 kg (1450 lbs) will be sufficient. The experiences ahead may, indeed, modify these target dimensions substantially.

1979 Plans.

The planned actions for the open ocean ADOM during 1979 are as follows:

a. Tests will be conducted on the various components of the ADOM to ensure proper operation and compatibility with the other components.

b. At-sea tests have been scheduled for 1979 to determine the horizontal holding capacity of the anchor, peak tensions experienced during lockup of the anchor, reliability of line payout, anchor module hydrodynamic stability during descent, and ability to set the subsurface buoy at 100 meters depth below the surface. Computer programs will be developed to provide analytical solutions to many of these problems. Particular emphasis is being placed upon the value of system impact forces on deployment and anchor lockup. The influence of current shear on the amount of mooring line payed out will be closely examined. A scheme to adjust the subsurface float to 100 meters will be analyzed and physically modeled.

c. In the electronics and sensor development, the lithium battery tests will be completed, a drift test of the sensor cable and sensors will be conducted, the array and processor configuration will be finalized, the telemetry system for use with the U.S. Air Force LES 8/9 satellites defined, and a moored test of the entire electronics package will be conducted.

d. Open ocean ADOMs will be fabricated and assembled in preparation for the aircraft drop of an open ocean ADOM in March of 1980.

The planned actions for the Arctic ADOM during 1979 are as follows:

a. The concept validation model (CVM) design will be completed using a manually operated ice drill system. The actual drill probe will be designed to be manually operated, i.e., without its final electronic control system, but will be dimensionally identical to the proposed Arctic ADOM drilling system.
b. The CVM ice drill system will be fabricated and in-house testing and checkout performed.
c. A series of tests of the CVM will be performed at the U.S. Army Cold Regions Research and Engineering Laboratory in Hanover, New Hampshire, simulating an Arctic environment.
d. The design of the Advanced Development Model (ADM) of the Arctic ADOM will be completed. The ADM will be a complete automatically operated, self contained ice drilling system.

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SECTION I
INTRODUCTION

1.1 PURPOSE.

This document details the technological accomplishments in the Air Deployed Oceanographic Mooring (ADOM) program during 1978.

1.2 BACKGROUND.

Technology is being developed for deploying oceanographic sensors from an aircraft in two regions of the world's oceans: the open ocean and the polar seas. A wide variety of scientific investigations can be pursued with air deployed oceanographic moorings which can be configured to meet specific scientific requirements. Also, a number of important oceanographic studies could be accomplished by deploying oceanographic moorings through the polar sea ice from long range aircraft. Two corresponding systems are being developed: an open ocean ADOM and an Arctic ADOM.

Both systems are presently configured to measure temperature, conductivity, and pressure. However, the systems have sufficient flexibility to allow the addition of other types of sensors.

1.3 PROJECT ORGANIZATION.

The ADOM Feasibility Study is being conducted under the direction of Dr. Eugene A. Silva, Ocean Science and Technology Division, Ocean Technology Program (Code 485), Office of Naval Research. The project was divided into technological areas as follows:

a. Open ocean moored system:

    (1) Mooring Mechanics - Mr. R. Walden, Woods Hole Oceanographic Institution.

(2) Hydrodynamics - Mr. L. Bonde, EG&G Washington Analytical Services Center, Inc.

(3) Aero Mechanics - Mr. Edgar Reed, Naval Air Development Center.

(4) Electronics - Dr. E. Softley, Ocean Electronic Applications, Inc.

b. Arctic ocean system:

(1) Mooring Mechanics - Mr. R. Walden, Woods Hole Oceanographic Institution

(2) Arctic Engineering - Dr. Robert Corell, University of New Hampshire

(3) Hydrodynamics - Mr. L. Bonde, EG&G Washington Analytical Services Center, Inc.

(4) Aero Mechanics - Mr. Edgar Reed, Naval Air Development Center.

(5) Electronics - Dr. E. Softley, Ocean Electronic Applications, Inc.

1.4 ENGINEERING PARAMETERS FOR ADOM.

Table 1-1 shows the engineering design parameters for the ADOM. These parameters have been derived directly from scientific requirements with the addition of known ocean characteristics. In addition, design current profiles for the operational and survival conditions are shown in Figure 1-1. Profiles of relative velocity for the Arctic Ocean are shown in Figure 1-2. The current profiles represent a summary of the general experience of the ADOM team (including oceanographers) with considerable attention to previously formulated engineering requirements for other systems.

TABLE 1-1. ENGINEERING PARAMETERS FOR ADOM

Sea State	
Operational	4
Survival	6
Water Depth (m)	6000
Measurement Depth (m)	100 - 1500
Sensor known depth accuracy (m)	± 1
Number of Sensors	240
Sensor Spacing (m)	20 to 200*
Temperature Accuracy (^{o}C)	± .01
Sampling Rate (minutes)	10 to 60*
Frequency of Data Transmission (weeks)	1 to 4
Operational Life	Longer than 6 months

*Adjustable prior to packaging

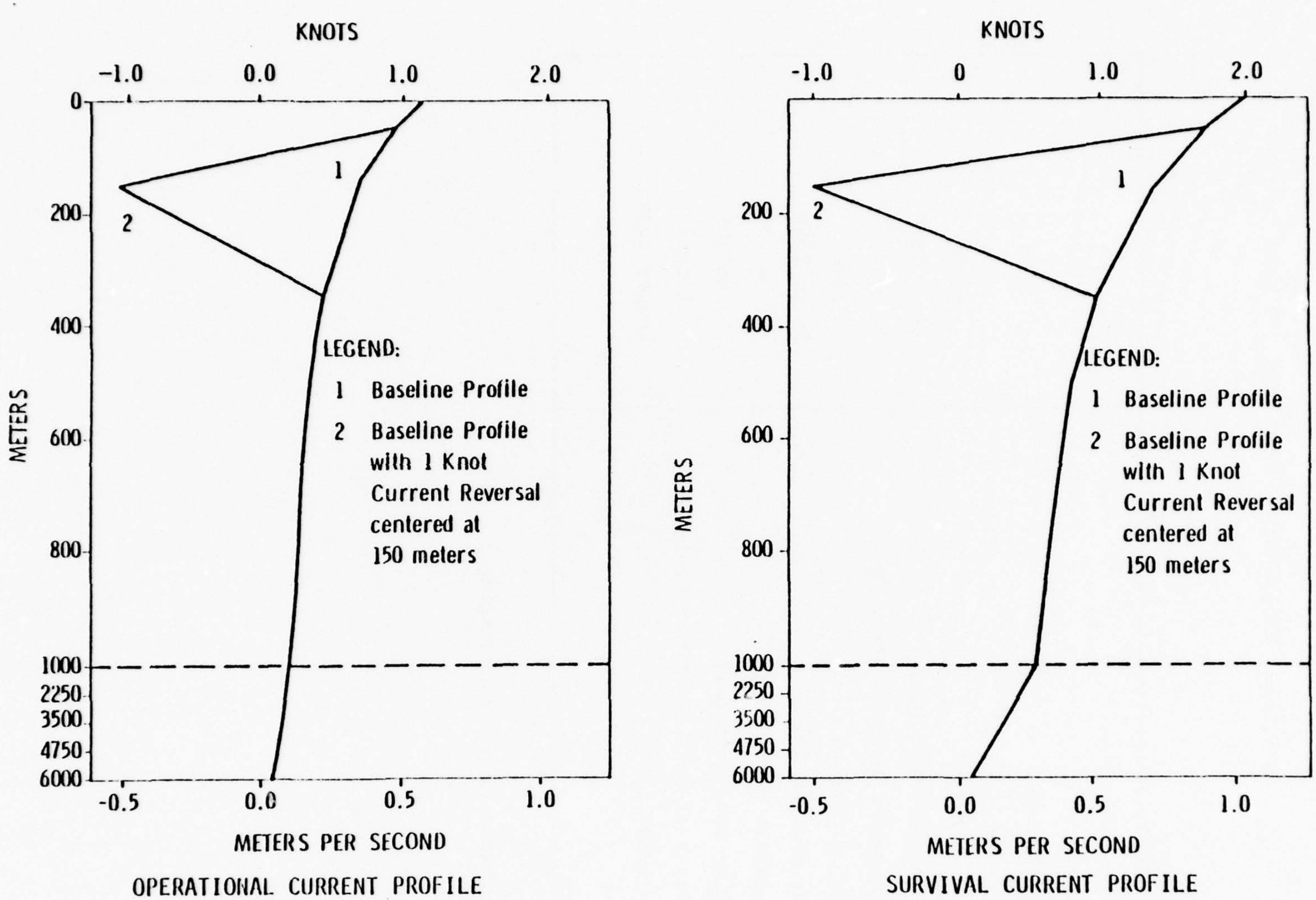


Figure 1-1. Open Ocean Operational and Survival Current Profiles

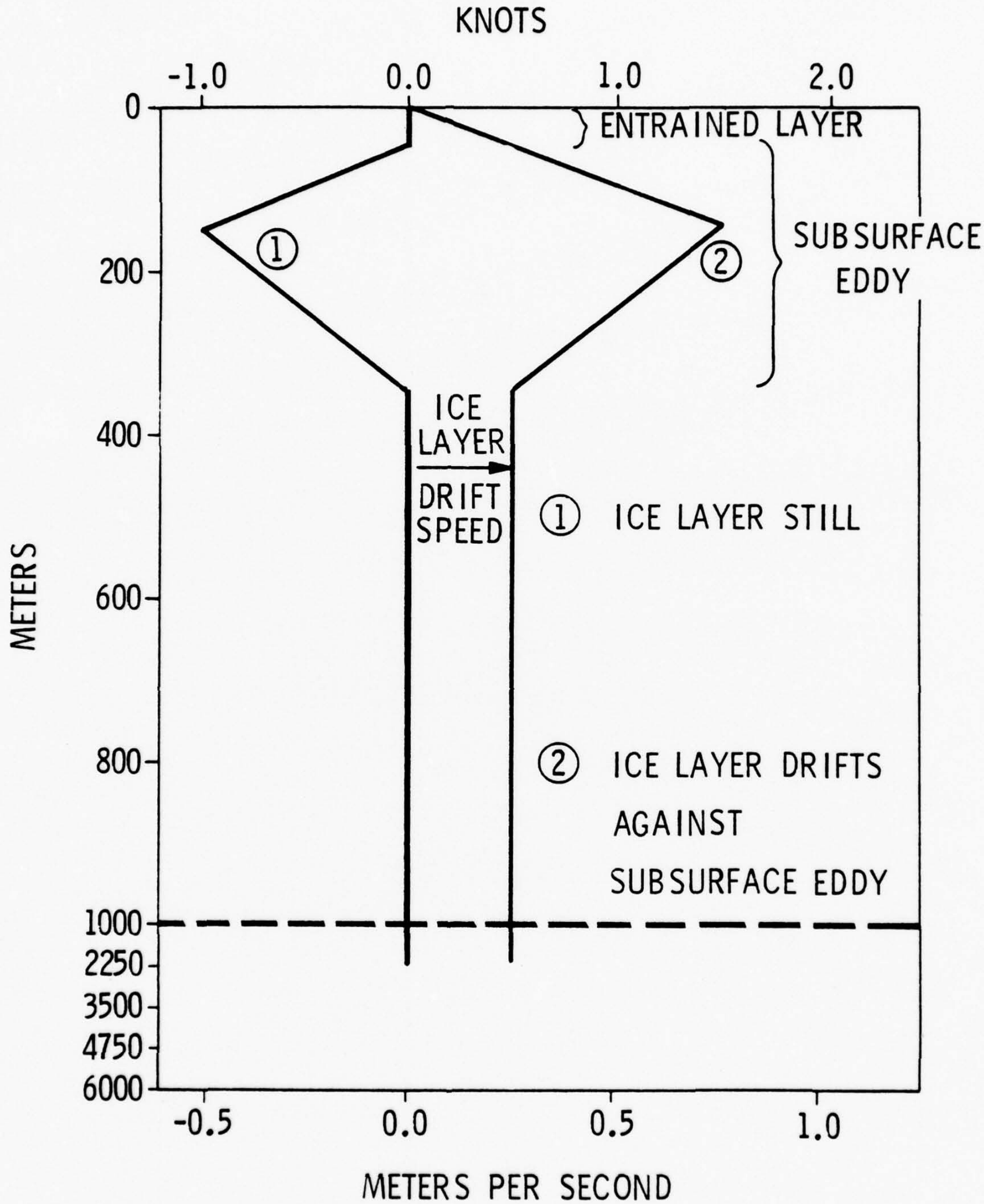


Figure 1-2. Profiles of Relative Velocity for Arctic Ocean

SECTION II

FINDINGS - OPEN OCEAN ADOM

2.1 GENERAL.

The ADOM designers must consider the four stages in the operational life of the device:

- Manufacture and Inventory,
- Transport and Release,
- Impact and Deployment, and
- Operation and Recovery (optional).

A successful design must identify and address all salient issues within these areas and balance them into a coherent system. The developing design is continually compared to the requirements of these four areas and adjusted accordingly.

For example, the ADOM weight, shape, and balance have been controlled from the outset for carriage and release from under the wing of a typical Naval aircraft of opportunity, taking into account take-off and landing loads and clearances, as well as delivery radius. For the time being, however, prototype R&D models will be carried within the fuselage of cargo aircraft and launched using standard freight release methods. This avoids the great cost of certification (as described in Appendix A) of ADOM as a wing-released store until the in-water aspects of the design are well established.

During 1978, the ADOM concept was studied in six major areas:

- Structure and Packaging,
- Material Properties,
- The Anchor Assembly,
- The Surface Tether,
- The Decelerator Assembly, and
- Electronic and Sensor.

At year's end, attention was turning to the hydromechanics of the anchor drop and preparation for an at-sea deployment of the key sub-assemblies of an ADOM system during FY80.

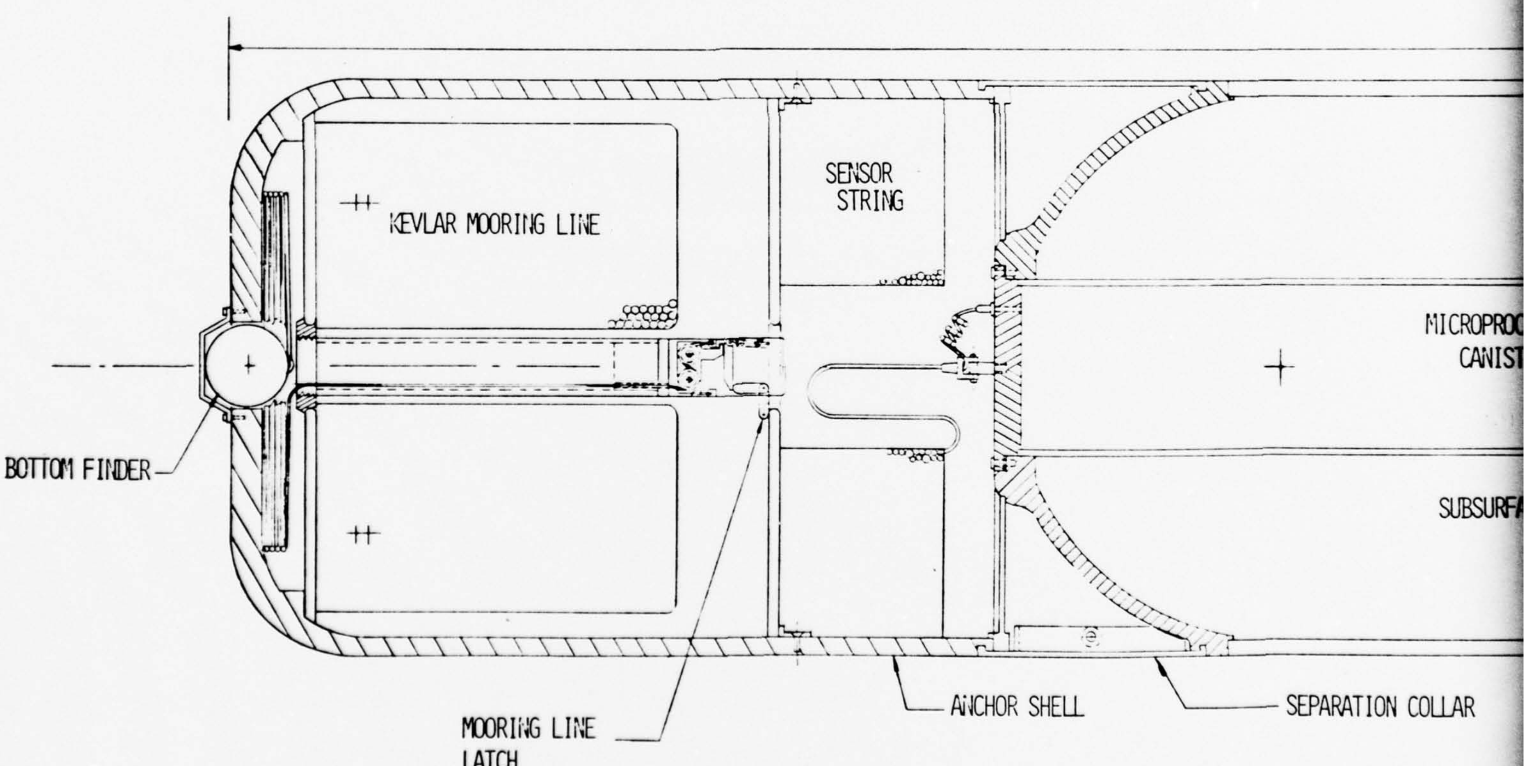
2.2 STRUCTURE AND PACKAGING.

The open ocean ADOM is shown in Figure 2-1. It shows the parachute chamber attached to the end of the electronics canister that runs through the surface float by a separation collar. The space between the parachute chamber and the surface float is reserved for the telemetry antenna.

The surface float is a cylindrical annulus of syntactic foam, covered with a fiberglass jacket for additional protection. The telemetry electronics and batteries are contained in a pressure housing. A second separation collar links the electronics canister to the subsurface buoy. The tether, which provides a structural and telemetry link between the subsurface buoy and the surface float, is housed in the space between them.

The subsurface buoy is a hollow, rigid aluminum tank with hemispherical ends. A central tube houses and supports the electronics for controlling the sensors and recording the data they gather.

The anchor assembly is coupled to the subsurface buoy by a third separation collar. The anchor itself is a heavy wall cast ductile steel housing. Four sub-assemblies are contained within the anchor housing shown in Figure 2-1. The sensors and their electromechanical connecting cable are stored in the top of the shell, nearest the subsurface buoy. The mooring line is coiled below the sensor cable and separated from it by a guide plate. A heavy post mounted in the center of the mooring line coil holds the line locking mechanism that clamps the subsurface buoy at the desired mooring depth. The bottom-finding plumb bob



SENSOR
STRING
KEVLAR MOORING LINE
MICROPROC
CANIST
BOTTOM FINDER
SUBSURFA
ANCHOR SHELL
SEPARATION COLLAR
MOORING LINE
LATCH

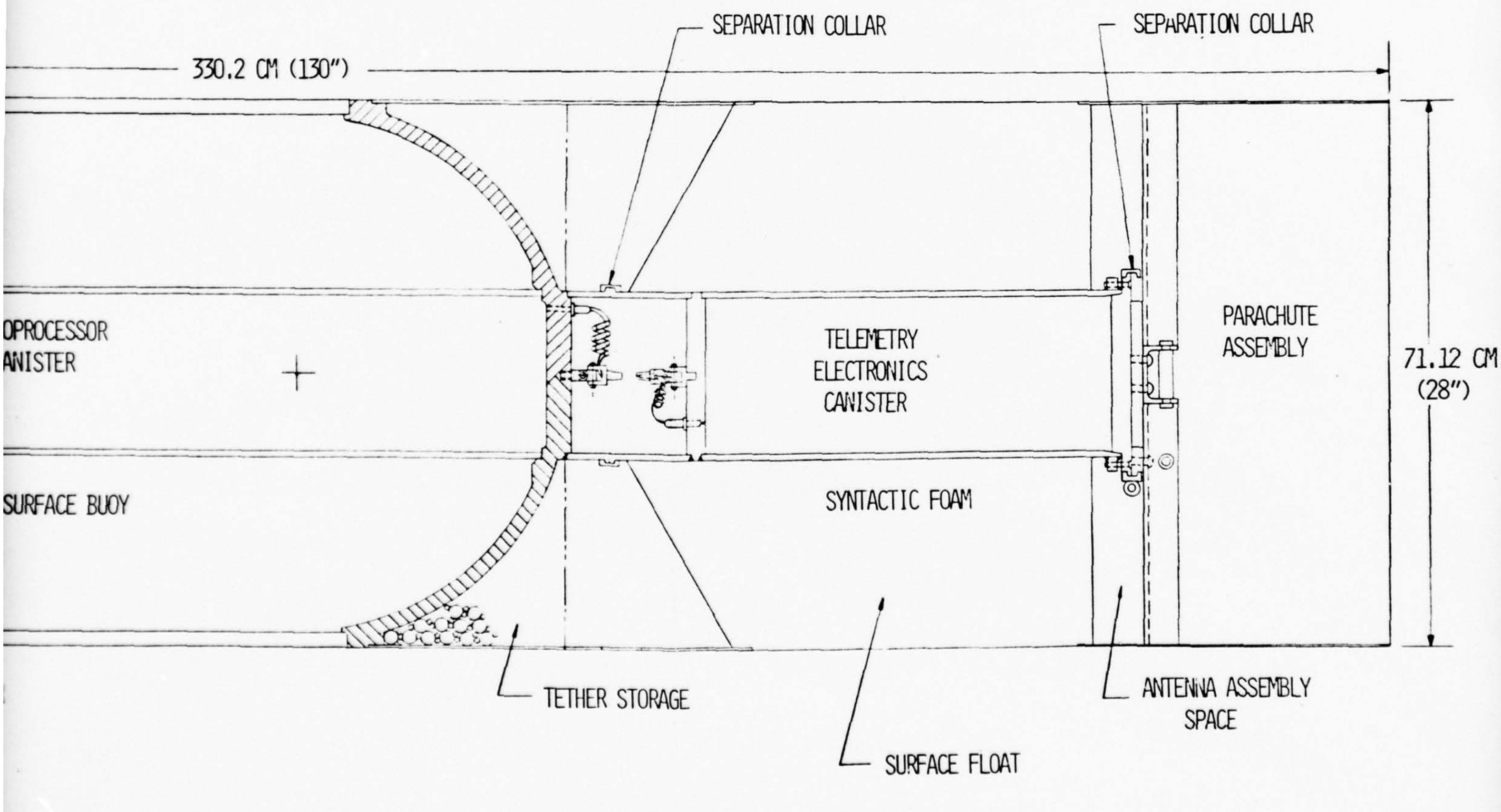


Figure 2-1. Open Ocean ADOM

is mounted in the end face of the anchor shell.

Figure 2-2 is a sketch of the open ocean ADOM when deployment is complete.

2.3 MATERIAL PROPERTIES.

In 1978 samples were obtained of the mooring line components and their engineering properties tested. Stress-strain and ultimate tensile strength tests, as well as creep and torsional tests were conducted. Samples included the rubber shock absorber used in the tether, the double-armor electromagnetic cable, and the aramid fiber (e.g. Kevlar® Dupont) mooring line. In most cases several sizes or constructions were tested.

An empirical formula was fitted to the stress-strain measurements for the rubber shock line and used in the hydromechanical analysis of the tether. A technique for molding an "eye" at the end of the rubber was developed and tested.

Several aramid fiber lines were evaluated. The stress-strain and creep tests were of particular interest because the nominal depth of the subsurface buoy is less than two percent of the design water depth. Thus, elongation of the mooring line has a large effect on buoy depth. This must be accommodated by the bottom-finder mechanism. It was found that creep adds about 50 percent to the initial elongation during the first day of loading, but practically nothing thereafter.

As part of the material testing program, the mooring sketched in Figure 2-3 was set off Bermuda on 17 November and successfully recovered on 18 December 1978. None of the components were damaged.

The modulus, yield point, and ultimate strength of the EM sensor cable were measured in a tensile testing machine. The values obtained

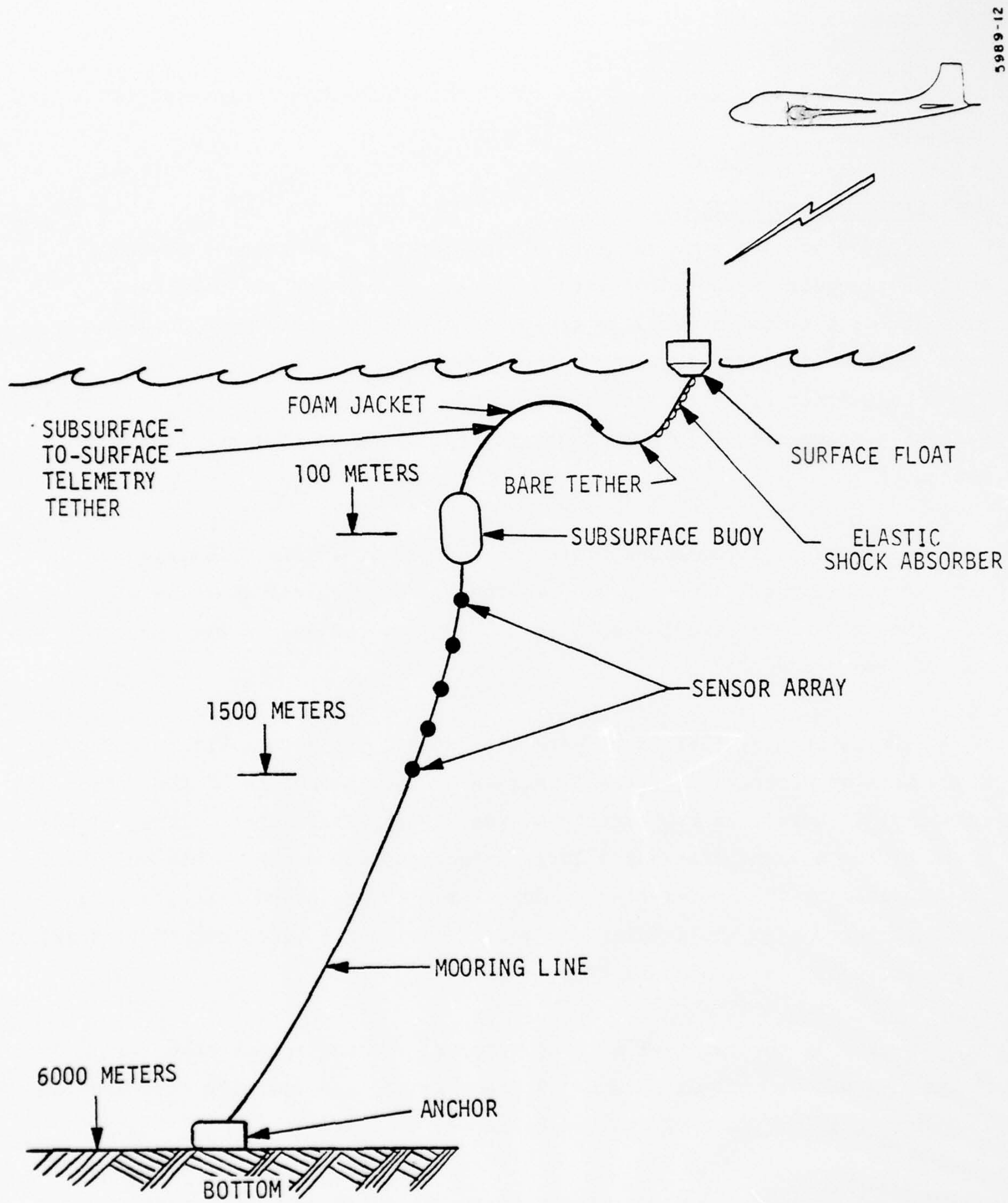


Figure 2-2. Open Ocean Moored System

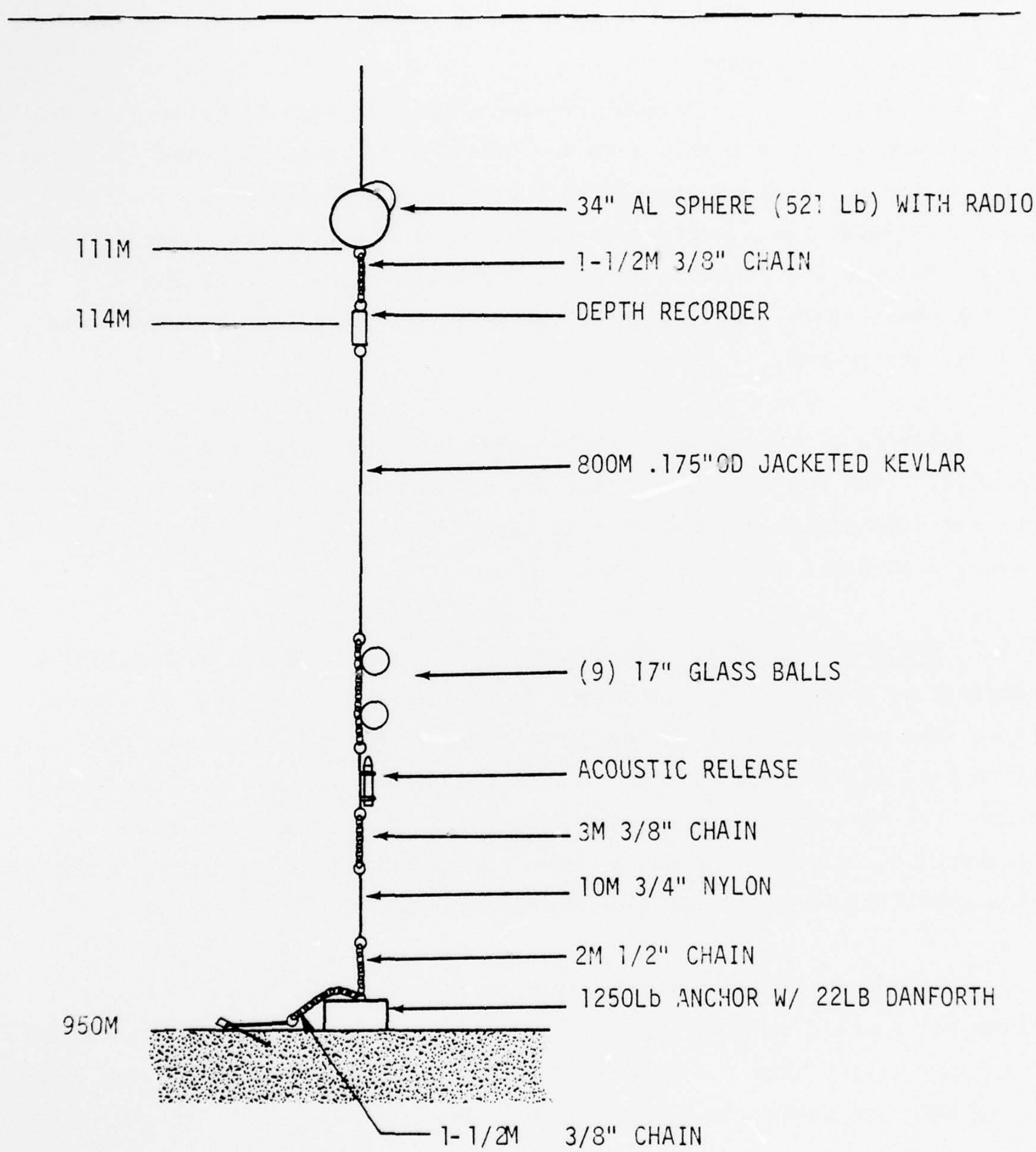


Figure 2-3. ADOM Test Mooring

were used in the analyses of the hydromechanics, and will be used in the studies of the deployment anchor drop.

2.4 THE ANCHOR ASSEMBLY.

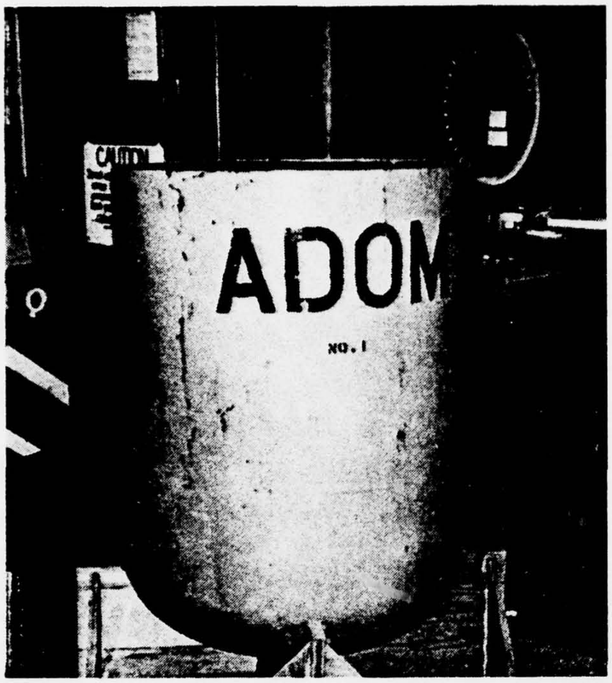
Upon splash down, the ADOM releases the parachute assembly from one end and the anchor assembly from the other, leaving the coupled float and buoy on the surface. During 1978, a prototype full scale model of the anchor assembly was constructed and tested in the laboratory and in shallow water. Figure 2-4 consists of several photographs of the assembly. During these tests, the design of the mooring line lockup mechanism was refined and proven.

Analysis of the in-water fall stability of the anchor was conducted in 1978. Tank and lake drop tests are planned in early 1979 to determine whether stabilizing devices such as fins, flaps, or a drogue are needed to assure a straight smooth descent.

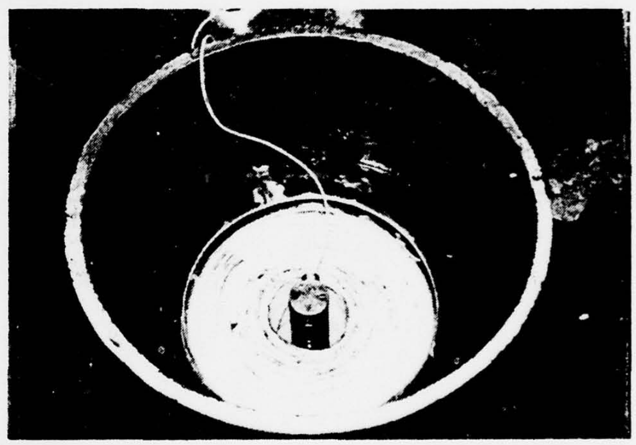
2.4.1 THE BOTTOM FINDER. The bottom finder concept shown on Figure 2-1 consists of a lead weight connected to the mooring line latch by a wire rope. The impact of splash down shatters a frangible cover over the plumb bob, allowing it to fall beneath the anchor shell. When the weight touches bottom, the pendulum wire goes slack, triggering the latch. A trigger lock prevents the splash down transient from latching the mooring line until the anchor is at a depth of about 500 m.

This bottom finder concept requires that both the anchor and the plumb bob descend smoothly, so that the suspension wire does not go slack until the weight hits the bottom. The length of the suspension wire must be adjusted to accommodate three variables:

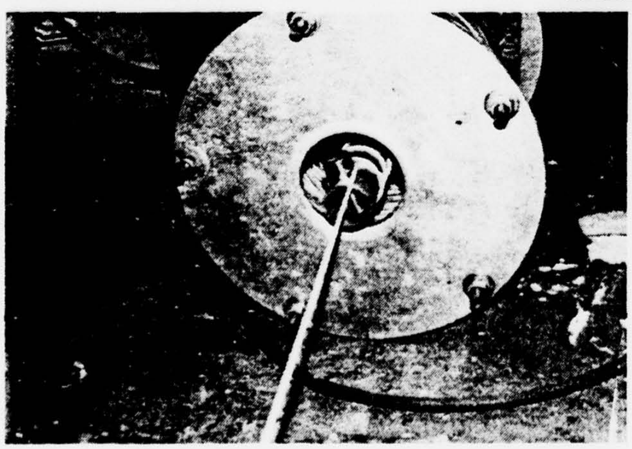
- the desired operating depth of the subsurface buoy,
- the stretch and creep of the sensor and mooring lines as the subsurface buoy is submerged, and



a. The Anchor Shell



b. The Line Latch



c. Assembled

Figure 2-4. The Anchor Assembly

- the excess mooring line that will be deployed because of the variation of the ocean current speed with depth.

Analytical and experimental work are planned for early 1979 to evaluate the impact of these factors on the bottom finder concept.

2.4.2 THE MOORING LATCH. When the bottom finder detects the ocean bottom, the mooring latch must quickly, smoothly, and securely stop further deployment of the mooring line without weakening the line itself. The device shown on Figure 2-4 (c) uses the friction of the mooring line with the center post as a brake. So long as the transverse latch pin is retracted, the turns spooling from the inside of the mooring line coil are free to slide off the end of the central post. At bottom-impact, the latch pin is thrust out, capturing the line between the post and the hole in the separator plate. Further turns are caught on the post and cannot slip off the end.

Analytical and experimental tests were conducted during 1978 to evaluate this device. It was found that latching was quick, smooth, and secure, but that the mooring line could be materially weakened if the diameter of the latch pin is too small. The analyses and experiments also confirmed that latching the line when only a short length has been deployed can break the line. The stretch available from the 1500 m sensor array plus a few hundred meters of mooring line are sufficient to reduce this transient spike to acceptable levels when the large latch pin shown in the figure is used.

2.5 THE SURFACE TETHER.

The ADOM surface float supports a telemetry antenna. A tether moors the float to the subsurface buoy and conducts data from the processor in the subsurface buoy to the transmitter in the surface float. However, the tether provides a less obvious but no less important third function.

Since virtually all energy in the ocean mass enters through the water surface, it is the upper layer that is the most energetic and shows the greatest response to weather. It is the tether line that, on the one hand allows the ADOM to accommodate a range of environmental variation, and on the other hand, protects the ADOM from damage by environmental extremes. The tether allows the surface float to ride 10 foot waves in the operational current profile shown on Figure 1-1, while protecting the delicate electrical conductor from wave damage. When the current exceeds the operational profile speed, the tether submerges the surface float to a safe depth. On the other hand, in very low currents approaching still water, the tether must not foul.

A fourth factor constrains the tether design. Small errors in the deployed length of the mooring line produce large errors in the operating depth of the subsurface buoy. A one percent error in the length of the mooring line may result in as much as a 50 percent error in the buoy depth. The tether must provide its essential functions while accommodating these anchor errors. Finally, the volume of the tether itself must fit within the space available in the ADOM deployment package and deploy smoothly from it.

Two design approaches were found that meet the technical requirements described above. One relied almost entirely on the stretch of a large elastic thong to accommodate both wave action and current variation. It was rejected because the second approach not only met the design requirements, but at lower line tension and less storage volume.

The ADOM buoyant tether is composed of three segments as illustrated in Figure 2-5. Its basic element is approximately 300 meters of a small double armor cable containing a single insulated signal conductor and covered with a plastic jacket for corrosion protection. The 122 m length nearest the subsurface buoy is covered with a foamed polyethylene jacket so that its net buoyancy is half the immersed weight of an unjacketed cable; that is, the buoyancy of the foam jacket is 150 percent of the immersed cable weight. The next 122 m is not foamed, just jacketed. The cable is clamped to the end of a 15 m segment of elastic rubber, and then 53 m are coiled around the rubber thong. The thong and wire are joined and connected to the surface float.

The stretch of the rubber thong holds nearly constant tension as the float rides the crests and troughs of 10 foot waves. The EM wire coiled around the thong will come taut well before the thong has stretched to the breaking point; on the other hand, the surface float lacks sufficient buoyancy to stretch the thong to the point that the EM wire comes taut, even when the drag due to the survival current is added.

The combination of bare and foam jacketed cable supports the tether in periods of low currents, yet even in no current, none of the tether floats on the surface where choppy waves might foul it.

Figure 2-6 shows six views of the buoyant tether. The shape of the tether is shown in 10, 50, and 100 percent of the operational current profile, both when the anchor is correctly deployed and when 50 m excess anchor line has been released in a water depth of 6000 m.

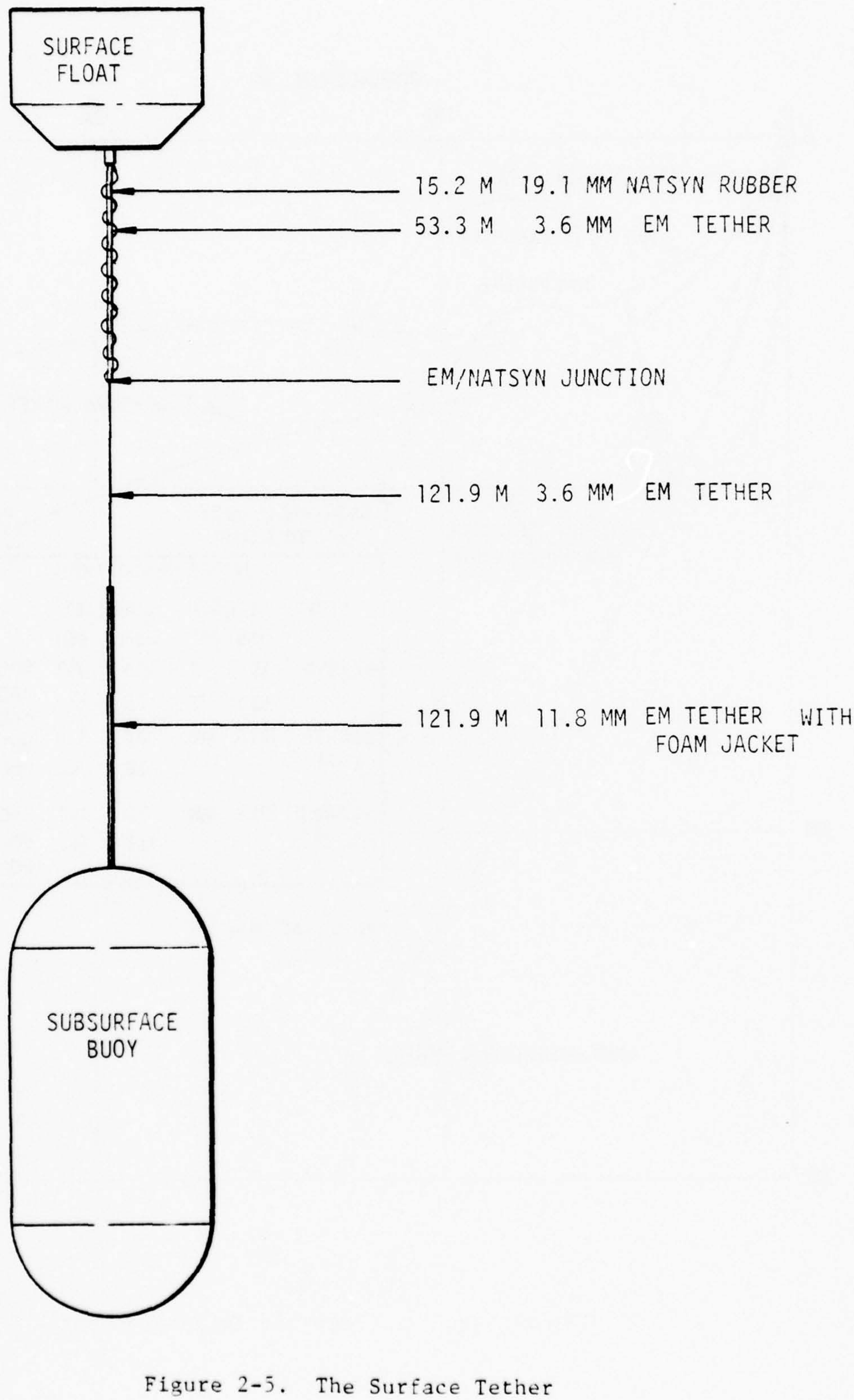
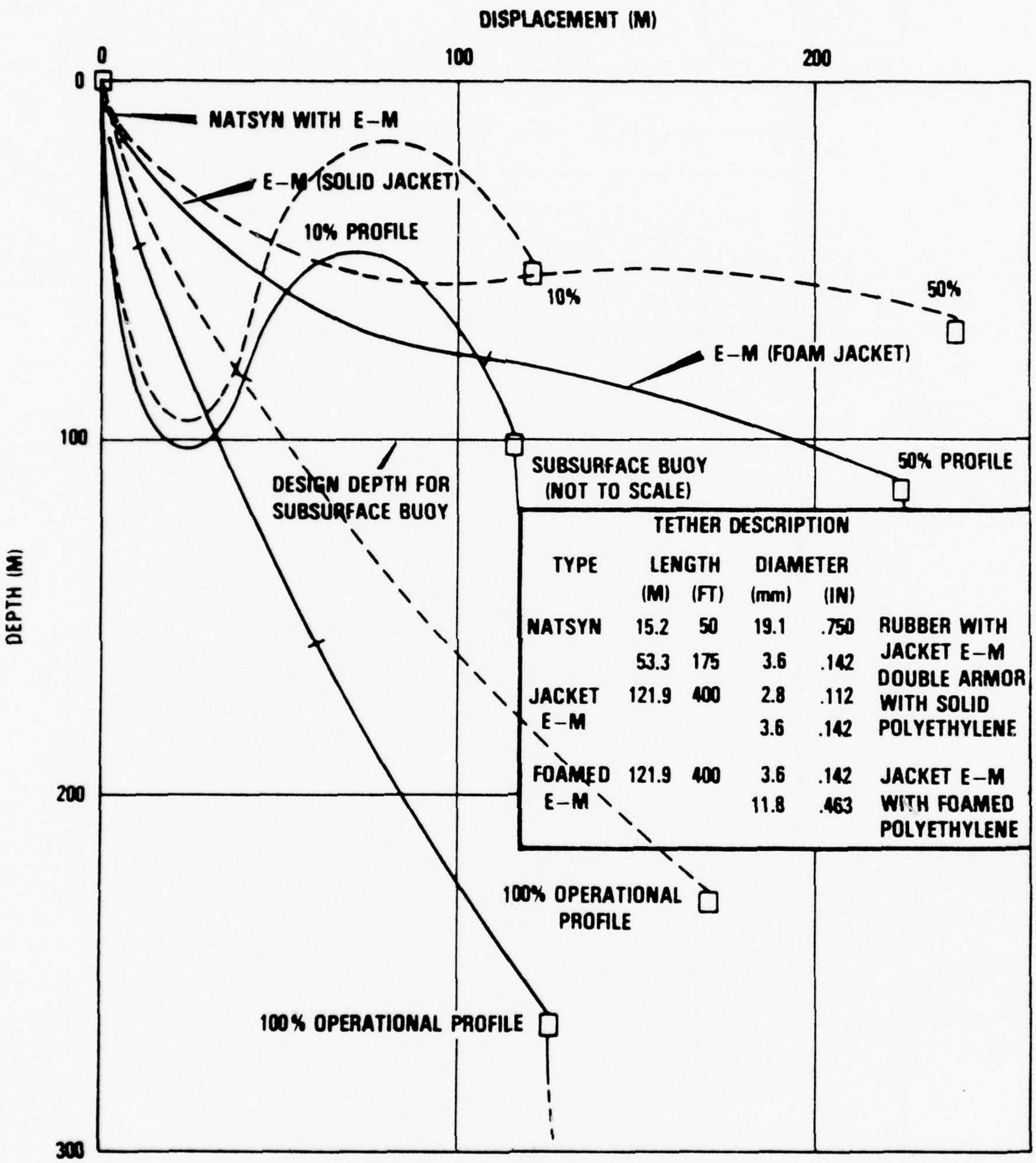


Figure 2-5. The Surface Tether



TETHER DESCRIPTION

TYPE	LENGTH (M)	LENGTH (FT)	DIAMETER (mm)	DIAMETER (IN)	
NATSYN	15.2	50	19.1	.750	RUBBER WITH
	53.3	175	3.6	.142	JACKET E-M
					DOUBLE ARMOR
JACKET E-M	121.9	400	2.8	.112	WITH SOLID
			3.6	.142	POLYETHYLENE
FOAMED E-M	121.9	400	3.6	.142	JACKET E-M
			11.8	.463	WITH FOAMED
					POLYETHYLENE

Figure 2-6. ADOM Buoyant Tether Concept

2.6 THE DECELERATOR ASSEMBLY.

The PCU-8/A parachute system is the prime candidate for use with the ADOM system in both under-wing and fuselage release methods. The PCU-8/A is currently used to lower the Navy CTU-2/A Aerial Delivery Container. It has been tested at air speeds up to 450 knots.

The PCU-8/A is a two-stage parachute system. Figure 2-7 shows an artists concept of the ADOM system at several moments during its descent to the sea surface.

Explosive release of the parachute cover deploys a small droque chute (approximately 1 m canopy). The drogue extracts the main canopy (10.4 m), a ring-slot parachute which is restricted from opening by a reefing line. After two seconds lapse, an explosive cutter allows the main canopy to open. The descent speed at water entry will be about 20 m/sec.

The main canopy has a drag area of about 41 m^2. The overall system weight, excluding canister and cover is about 30 kg (65 lb). Figure 2-8 shows several photographs of the PCU-8/A being packed into a mockup of the ADOM decelerator storage area.

Figure 2-7. ADOM Deployment

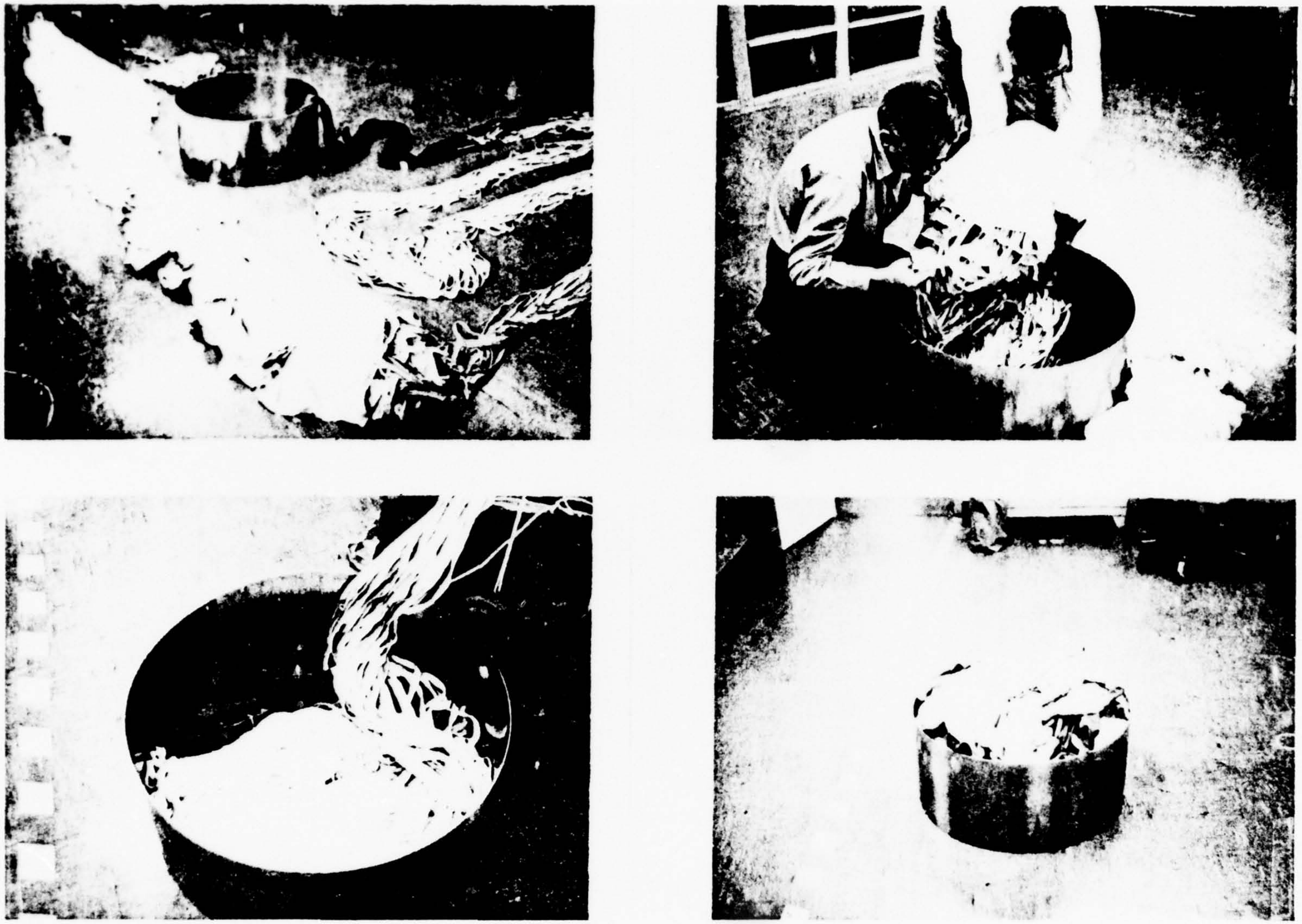


Figure 2-8. Packing the PCU-8/A in an ADOM mockup

2.7 ELECTRONIC AND SENSOR SUBSYSTEM.

The components that are included in the electronic and sensor system are shown in Figure 2-9. The ADOM processor with its data memory and power pack form the central electronic assembly. The segmented cable has terminations to allow the insertion of calibrated sensors. The assembly is terminated by an additional component which provides for cancellation of reflected signals from the end of the cable. Above the central processor is a cable to a surface float.

The electronic assembly, which consists of a processor, data memory and power pack, is housed in a 20.3cm (8 in.) diameter aluminum cylinder which can be made into a separate pressure housing in the ADOM buoy. With this housing, the electronic and sensor system can be considered to be a complete mechanical and electrical subsystem ready to be integrated in ADOM.

2.7.1 PROCESSOR. The Intersil IM 6100 CMOS microprocessor was selected for ADOM. The complete microcomputer is shown schematically in Figure 2-10. The assembly consists of boards which plug into a computer-type backplane or motherboard. The boards and their functions are:

AμP	Microprocessor, connection to computer
ACL	Real time clock, interval clock
ADA	Data acquisition, sensor operation
APR	PROM, permanent program storage
ARA	RAM, working program
ADX	External data storage interface
ATX	Data telemetry

Each board uses the same pin connection to the motherboard; and therefore, can be placed in any position.

In addition to these boards, an external crystal oscillator (TCXO) acts as a 1 MHz clock which is used for all timing functions, as well as

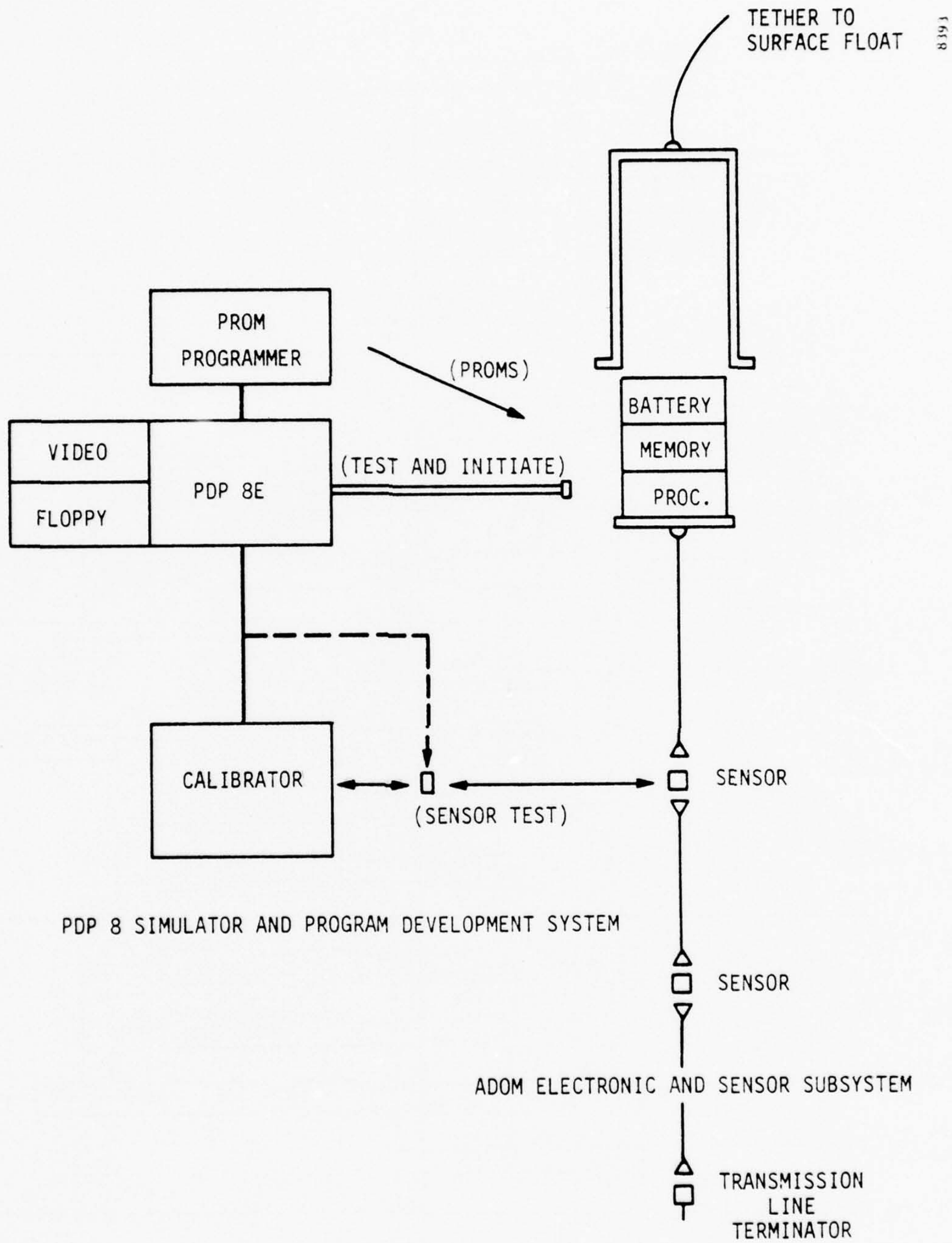


Figure 2-9. The ADOM Electronic and Sensor System

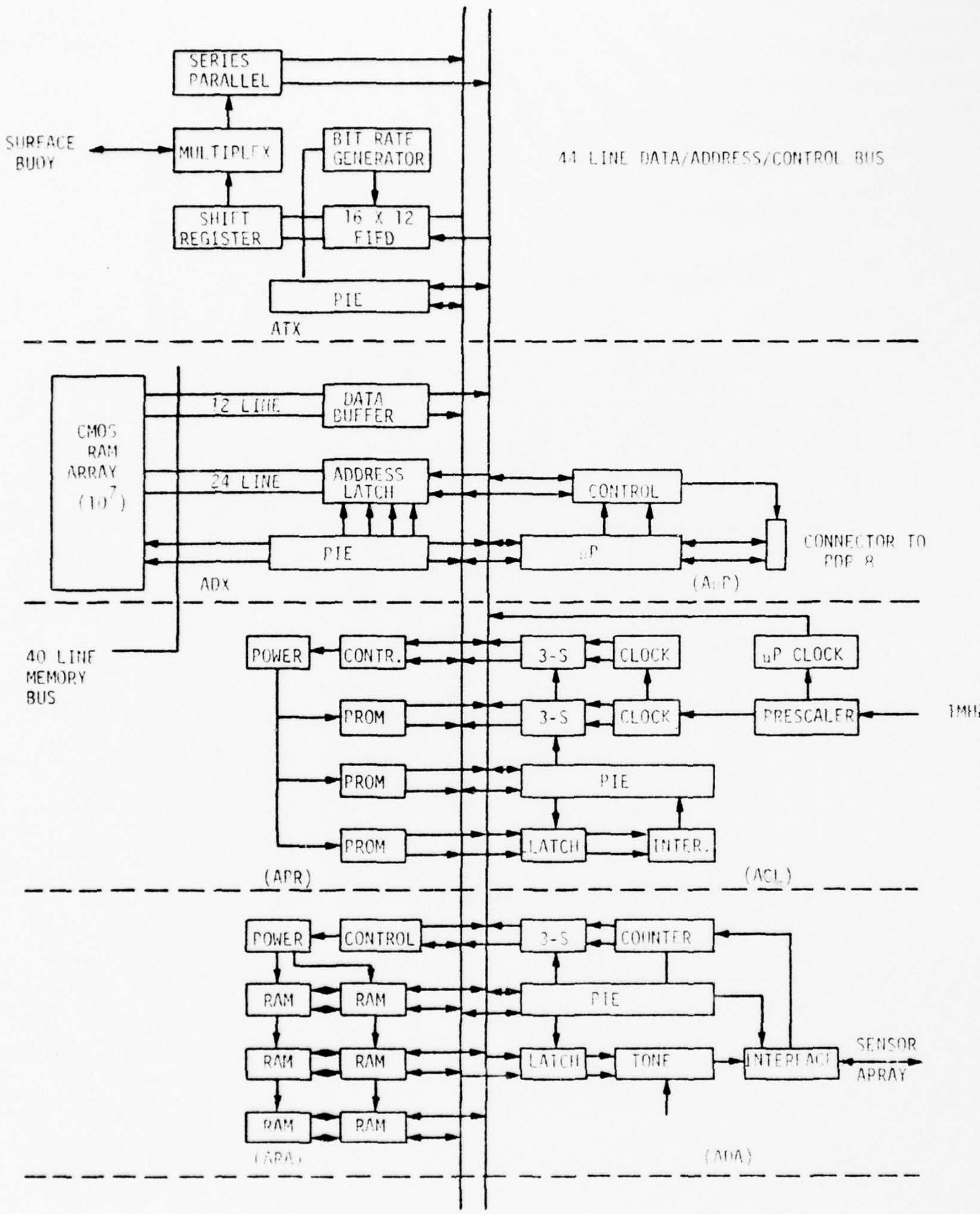


Figure 2-10. ADOM Microcomputer (As of 12/31/78)

the generation of command frequencies. The temperature of this oscillator is monitored directly and correction made to computed times for improved accuracy.

The complete processor is constructed of CMOS components. Originally intended for MOS PROMS, permanent program storage is now in 6603 CMOS EPROMS (6611 devices have also been used). Since the 6100 is memory oriented, a working RAM memory is necessary. The computer has the full 32K addressing of the PDP 8 minicomputer, but the total data acquisition can be achieved with 1K of PROM and 1K of RAM.

Software and hardware are being developed simultaneously, and to facilitate this, a PDP 8 with typical peripheral support can be coupled to the microcomputer. Thus, a program can be written (in any language) on the PDP 8. A RAM memory module replaces the equivalent EPROM module and the PDP 8 program written directly into ADOM. Direct readback of any part of the ADOM memory allows monitoring of the program operation. Special test programs with conventional break points are easily written, and hardware testing is rapid and very complete. Direct printout of the ADOM program and data are quickly effected. Once a program is evaluated and tested, it can be written directly into EPROMS from the PDP 8, and the EPROM board replaced in ADOM. As an example of the speed of the process, a 1K word program was written, debugged, and burned into PROMS in less than 4 hours.

Data acquisition from the addressable sensors is achieved by the technique shown in Figure 2-11. Four sequential tones are generated by the processor. They are superimposed over a D.C. voltage (used for sensor power) on the cable. The first tone is used to lock a reference oscillator in each sensor to that in the processor. The next three tones (one of eight) are compared with internally generated signals. Hence there are 8^3 or 512 unique addresses. Increasing the number of tones to 8, a maximum with the existing sensor hardware, allows 8^8 or over 50 million unique addresses.

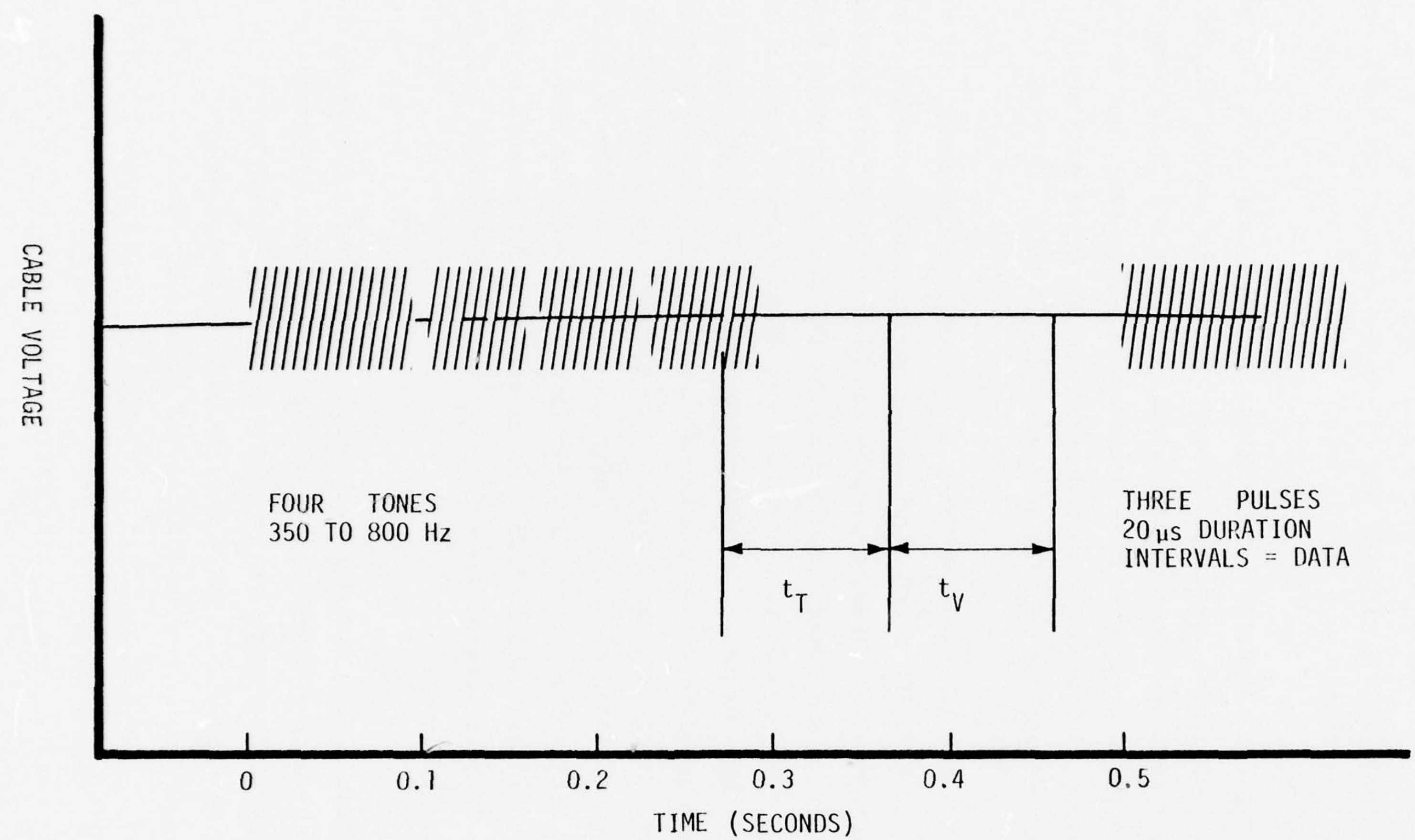


Figure 2-11. Sensor Cable Signals

The addressed sensor responds with three pulses, each of 20 microseconds (μs) duration and with separation times which are a function of temperature and voltage. The first of these allows determination of temperature to $\pm.1^{\circ}C$ accuracy over a $0-30^{\circ}C$ range. The second pulse allows correction to $\pm.01^{\circ}C$ accuracy. It should be noted that a large unused spectrum exists on the sensor cable and this allows ready addition of other wideband signals simultaneously with the array.

The sensors operate over a voltage range of 3.4 to 8.0 volts with a consumption at 5.0 volts (V) of 500 microampere (μA). Signal attenuation in the cable means that 240 such sensors can be integrated into a continuous 1500m array.

Considerable effort has been made in reducing the power consumption of the system. A variable speed microprocessor block, from 7.8 KHz to 1 MHz, is featured and the microprocessor adjusts its own clock frequency. Power strobing of large portions of the computer is also used, including the microprocessor itself. During intervals between data acquisition and processing cycles, over 90 percent of the total system is in a quiescent state with an internal clock repowering the system after a preset interval. Data acquisition cycles can be fixed, controlled manually, or made dependent on the data. The total processor operates from 3.4 to 10.0 V with an average power consumption of about 30 mW(at 5 V) for a 12-minute data acquisition cycle.

Two processors have been built (see Figure 2-12). The modules are constructed on 11.4 cm (4.5 in.) x 15.2 cm (6 in.) double sided p.c. cards which plug into a 44-conductor, wave-soldered, backplane. The total processor structure "floats" inside a 20.3 cm (8 in.) I.D. cylinder housing.

Almost 1000 hours of processor operations have been achieved in the laboratory. The first field test of the processor will involve a drifting buoy and a full-length sensor array at the Tongue-of-the-Ocean. For this test, a

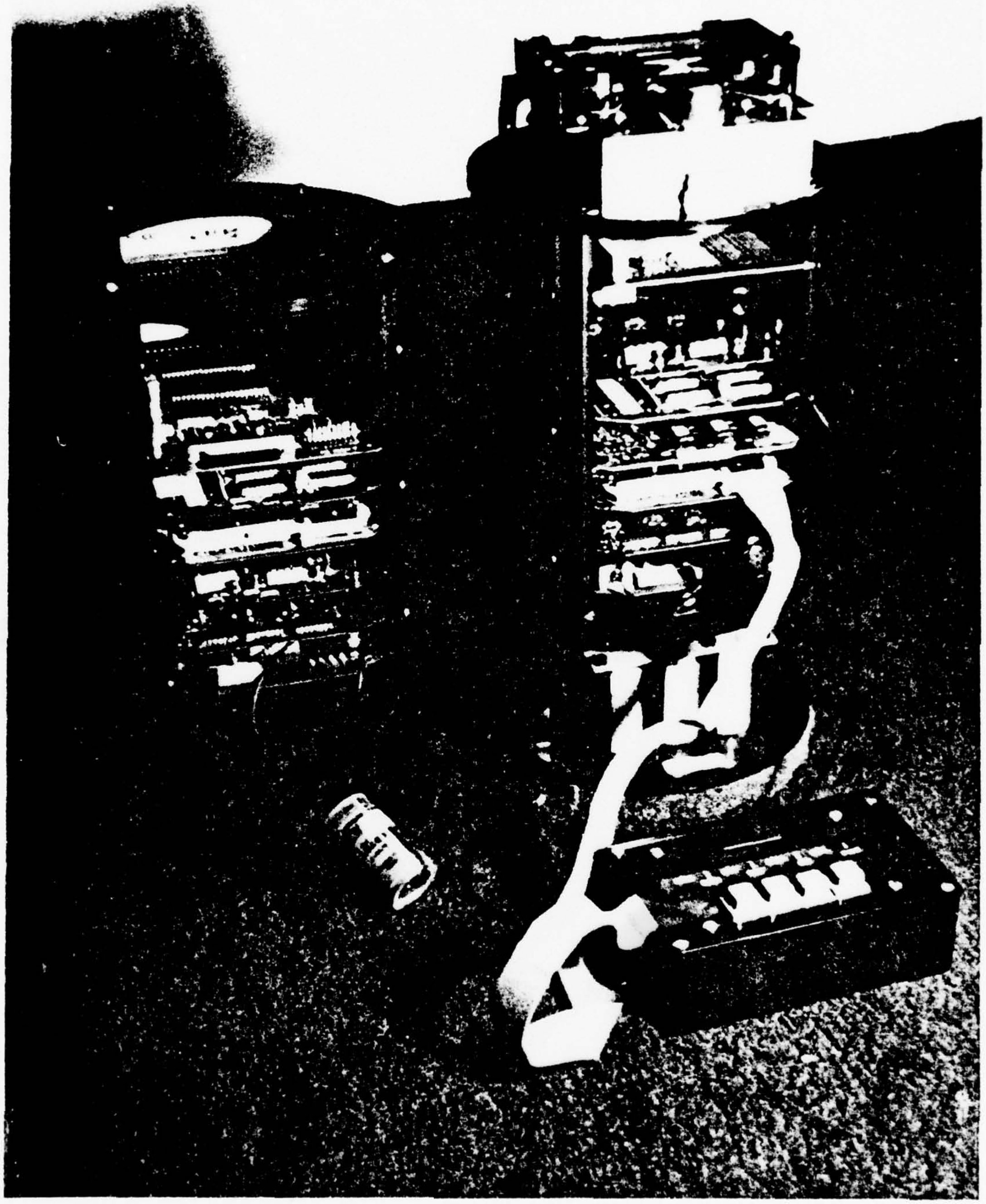


Figure 2-12. ADOM Processors

small tape recorder, operated by the microprocessor, will be used and this is shown in Figure 2-13 together with the buoy. The buoy used for this test is the prototype surface float for ADOM.

2.7.2 SENSOR ARRAY. The sensor decoder uses digital techniques. Each frequency received is compared with one generated in the decoder itself. The local oscillator is set by sampling a reference frequency. Any number of pulsed tones from one to eight are possible with only simple wire jumper changes needed to select the number and the actual address. The frequency bursts can be on the order of 50 ms in duration, but must have a 5 ms gap between tones. An important factor is that the decoder works over a cable voltage range of 4.1 to 7.5 V, and this eliminates the need for voltage regulation with its attendant increased currents. Table 2-1 summarizes the important characteristics of the approach.

The temperature sensor is quite simple. A 4528 CMOS pulse generator uses a thermistor for the timing circuit. The resulting pulse is differentiated to provide timing pulses at the start and stop of the 4528 pulse. Accuracies on the order of $0.1^{\circ}C$ over the range $0\text{-}30^{\circ}C$ are achieved, and this becomes $0.01^{\circ}C$ with suitable correction for the supply voltage variation. To determine the voltage, each sensor also transmits a pulse, the duration of which is a function of the supply voltage.

Figure 2-14 shows the sensor in its electronic packaging. Considerable effort was spent in minimizing the package dimensions since any increase in these would cause the overall sensor package to increase. The actual electronics assembly measures 48mm x 26mm x 22mm not including the connector pins. Conventional DIP packaging is used for the 9 integrated circuits which comprise the sensor. The dimensions could be reduced by employing hybrid construction of the bare chips themselves, but this was not deemed necessary at this stage.

Figure 2-13. Surface Float For Use In
Drift Test Of The Processor

TABLE 2-1. SENSOR CHARACTERISTICS

	N = 3	N = 4
No. of Unique Addresses	512	4096
Data acquisition Time (msecs)	510	590
Min. Cable Voltage (volts)	4.1	4.1
Max. Cable Voltage (volts)	7.5	7.5
Maximum No. of Sensors in 1500 m Cable (Power Limitation)	240	240
Cable Current For:		
50 sensors	18.6	18.6
100 sensors	40.9	40.9
(mA)		

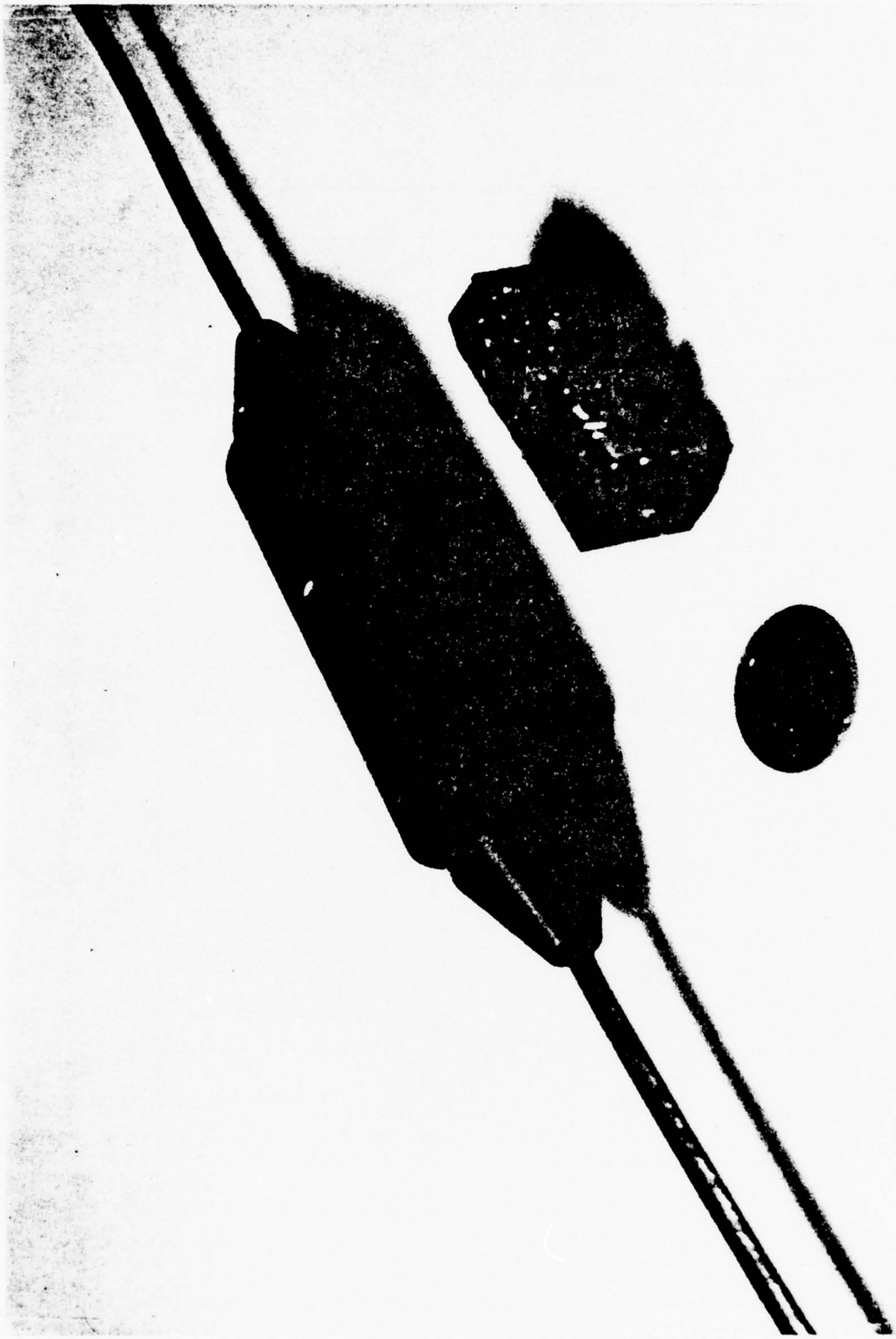


Figure 2-14. Sensor

The sensor housing and the cable terminations are constructed of hard anodized 6061-T6 aluminum. The cable terminations are held in place with threaded sleeves and the whole assembly locked in place, after assembly, with a pin which also provides the ground connection.

A laboratory simulation using 10 active and 90 dummy sensors (to simulate the cable loading) was made. A cable, with resistance and impedance characteristics to match the 1500 m sensor array cable, was used.

Ten prototype sensors have been constructed and are under evaluation. They will be packaged into a 1500 m array and deployed as part of a drifting test in the Tongue-of-the-Ocean.

The sensor cable has been finalized and 6000 m (20,000 ft) of the cable purchased for initial tests. Cable characteristics are:

Outside Dia	4.4 mm
Conductor	18 AWG
Armor	Double-steel 12T/23T
Resistance	19.6 Ω /km
Capacitance	160 pfd /m
Breaking Strength	8900 N
Yield Strength	6700 N @ 1.1% elongation
Wt. (Dry)	69.6 kg/km
Wt. (Wet)	44.4 kg/km

2.7.3 BATTERY PACK. Tests on Lithium D Cells at 20°C and -40°C continue. Tests were made at 500 mA, 8 mA and 0.75 mA cell current, and at duty cycles consistent with the above for nominal 1-year operation for telemetry, processor and memory operation, respectively. Only the telemetry batteries have been fully depleted. Figure 2-15 shows a plot of the cell voltage as

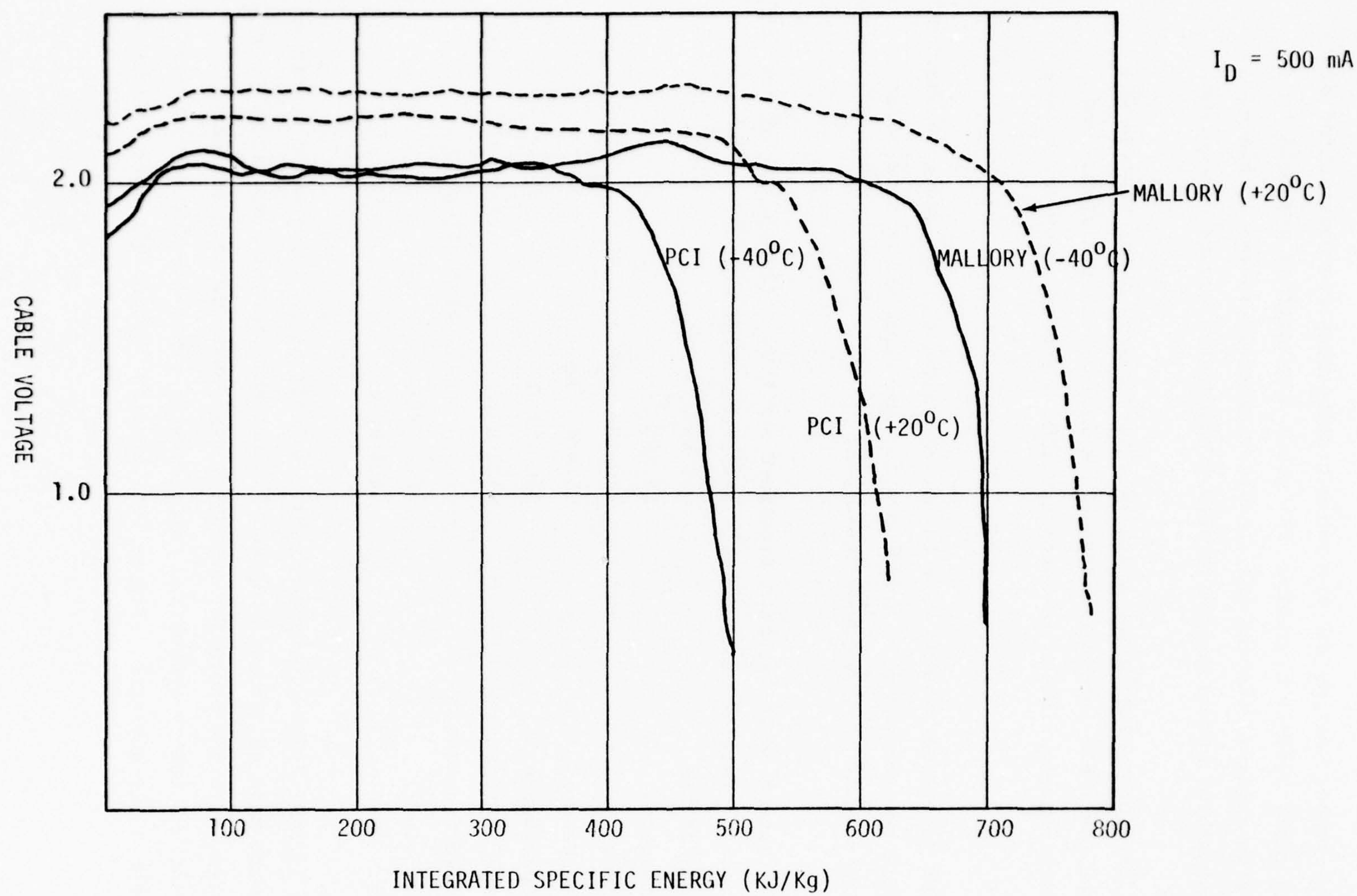


Figure 2-15. Lithium Batteries For Telemetry System

a function of integrated energy, relative to 1 kg of such cells. It is concluded that the Mallory batteries outperformed those from Power Conversion Inc. (PCI) under these conditions, and that at this current level, approximately 14% reduction of available energy occurs when the operating temperature is reduced from $+20^{\circ}C$ to $-40^{\circ}C$. The other tests are still incomplete except that, as expected, at lower current levels more specific energy is available.

2.8 TELEMETRY PACKAGE.

As originally conceived, two data telemetry schemes were envisaged. These included telemetry to an aircraft via a tethered surface buoy and acoustic telemetry to a drifting modified sonobuoy and continuing via RF link to the aircraft. With increased confidence in the survivability of the surface mooring and with changing user needs, the decision has been made to use an RF data link via the U.S. Air Force LES 8 and 9 satellites. No actual design work on the RF portions of the buoy hardware has been initiated.

Several conclusions have been made concerning layout and procedure. Figure 2-16 shows the component layout. The 6100 processor will act as controller, data formatter for transmission, and received command decoder. To minimize power, satellite relay will occur once daily provided the surface buoy is not submerged. Signals for the receiver will be routed to the processor with a simple interrupt routine to service the command. When the command is verified, the transmitter is powered and telemetry occurs. At 2400 bps and with 69 percent data efficiency, one day's data (10^5 bits) can be transmitted in 60 seconds. With 25 W to the buoy transmitter, the energy required per year for transmission will be a 550 kJ. If the receiver is open for 1 hour per day, the receiver power would need to be less than 1/2 W for comparable energy. If this can be achieved, then a 1-year telemetry link can be maintained with about 1-1/2 kg of batteries. This is consistent with surface float performance.

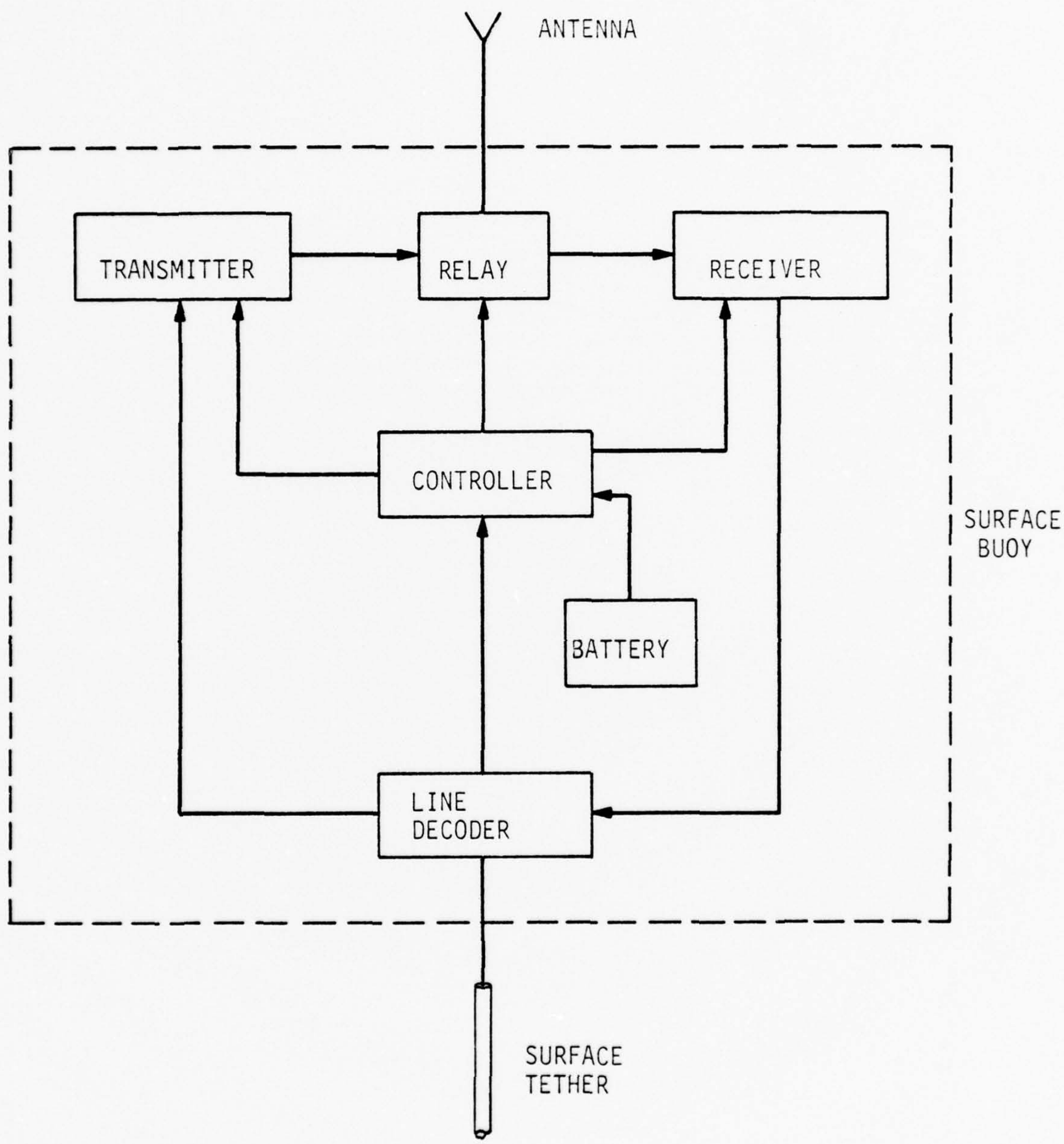


Figure 2-16. Surface Float Electronic System

SECTION III

FINDINGS - ARCTIC ADOM

3.1 GENERAL.

The Arctic ADOM system when deployed is shown in Figure 3-1. It consists of a support structure on the ice, a 1500 meter sensor string, and an ice drill at the end of the sensor string. The electronics and telemetry systems are located in the support structure.

Figure 3-2 shows the present arrangement of the Arctic ADOM. It employs erection legs to achieve vertical orientation. Figure 3-3 shows the ADOM ice drill, which is a battery powered recirculating hot water jet system. The goal is to be able to drill a 15.2 cm (6 in.) diameter hole through a maximum of 15.2 m (50 ft) of ice.

3.2 ARCTIC ENGINEERING.

In this year's efforts, a series of interrelated tasks were undertaken and are discussed below. They are described in greater detail in Reference 1.*

3.2.1 ANALYSIS OF ICE STATISTICS. A major area of unknown relates to the specifics of the ice that covers the Arctic Ocean: how deep it is, how much extends above the water, how convolved is the surface, and what slopes may be encountered? Ice thickness data for the Arctic is sparse and the various methods of obtaining thickness data are subject to serious deficiencies. Several attempts have been made to profile both the upper and bottom surfaces of the sea.

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* All references are listed after Section IV.

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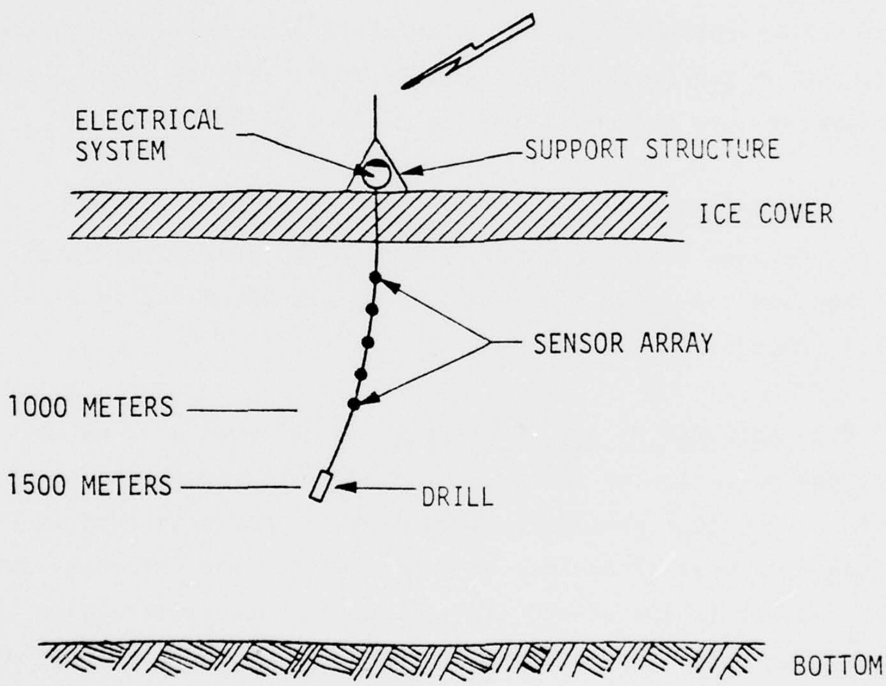

Figure 3-1. Arctic ADOM System Deployed

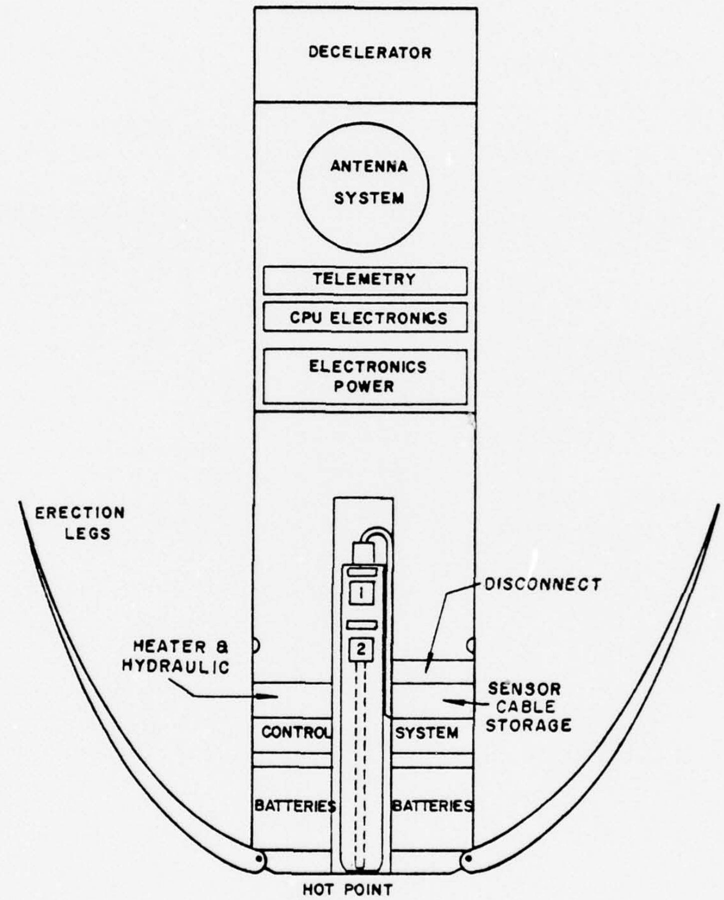

Figure 3-2. Arctic ADOM

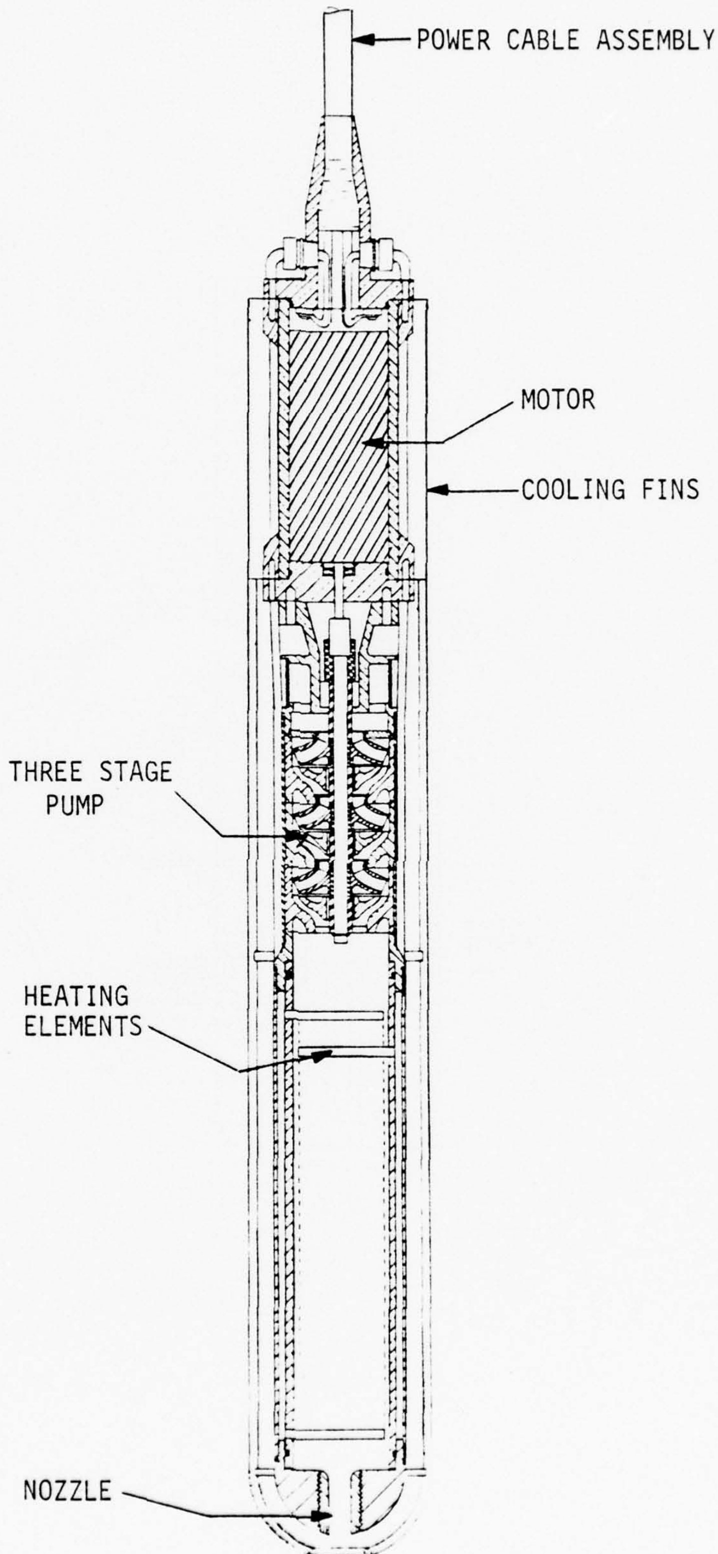

Figure 3-3. ADOM Ice Drill - CVM

Data from six major sources were obtained and analyzed. This published data suggests.

a. Surface texture maximum slope $20^\circ \pm 10^\circ$
b. Snow cover -- likely cover = 0.91 m (3 ft)
c. Seasonal variation = less than 1 meter total
d. Latitude variation - about 1 meter on mean, or about 3 meters total

These data cover a range of spacial distributions, seasons, and textures. They were made available as a series of data points, each an average of many measurements and are provided by most sources with a standard deviation. An assumption is, thus, implied that the data is Gaussian, but there is evidence that it approaches a Rayleigh distribution. The statistics, therefore, must be corrected for this obvious skewing. If one applies a judgmental correction for skewing, it is suggested that the maximum encountered ice thickness (99% probability) lies in the 15.2 to 16.8 meters range. It was decided to use an ice thickness of 15.2 meters as a basis for the Arctic ADOM design, implying that perhaps 1% of the deployments will fail due to thicker ice.

3.2.2 ENERGY REQUIREMENTS FOR THE ARCTIC ADOM. Data from previous studies 2, 3, 4* for determining the amount of heat required to drill, thermally, a hole through Arctic ice were employed to study the tradeoffs of hole size, drilling speed and power/energy required to accomplish the drilling. The analysis indicated that a 15.2 cm (6 in.) hole may be drilled in 53 minutes with about 35 kWh of power. Assumptions have been made on efficiency that makes this a reasonable expectation.

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* All references are listed after Section IV.

3.2.3 <u>DRILLING SYSTEM ALTERNATIVES</u>. Figure 3-4 shows the potential ADOM ice drilling systems. Eighty seven possible candidates that were considered are listed. They are grouped in four generic systems (plus a tactical solution). They involve eleven systematic approaches and rely on an over-lapping group of some 15 potential sources of energy.

The 87 candidates involve some combinations that are openly impractical, and some which may include a major flaw that merits immediate rejection, or indeed, causes it to be less effective than others under review. A four stage filtering process was used to eliminate candidates:

a. Examination of the several identified power sources to eliminate those found to be inappropriate for various reasons.
b. Examination of the over-all system concepts, and, where appropriate, identification of fundamental weaknesses was made.
c. A listing of the systems that remain was then made, combining the various surviving power sources, and systematic approaches.
d. These systems were then measured against a set of criteria.

The investigation of the eighty seven system configurations which were considered led to two candidates for the Arctic ADOM ice drilling system, each stemming from a different line of technology. One system employs hot water heated by an electric heat source, which is flushed at high velocities from the nose cone of the hot point. This is known as the hot water jet system. The second system uses water which has been electrically heated to scrub the ice in front of the hotpoint.

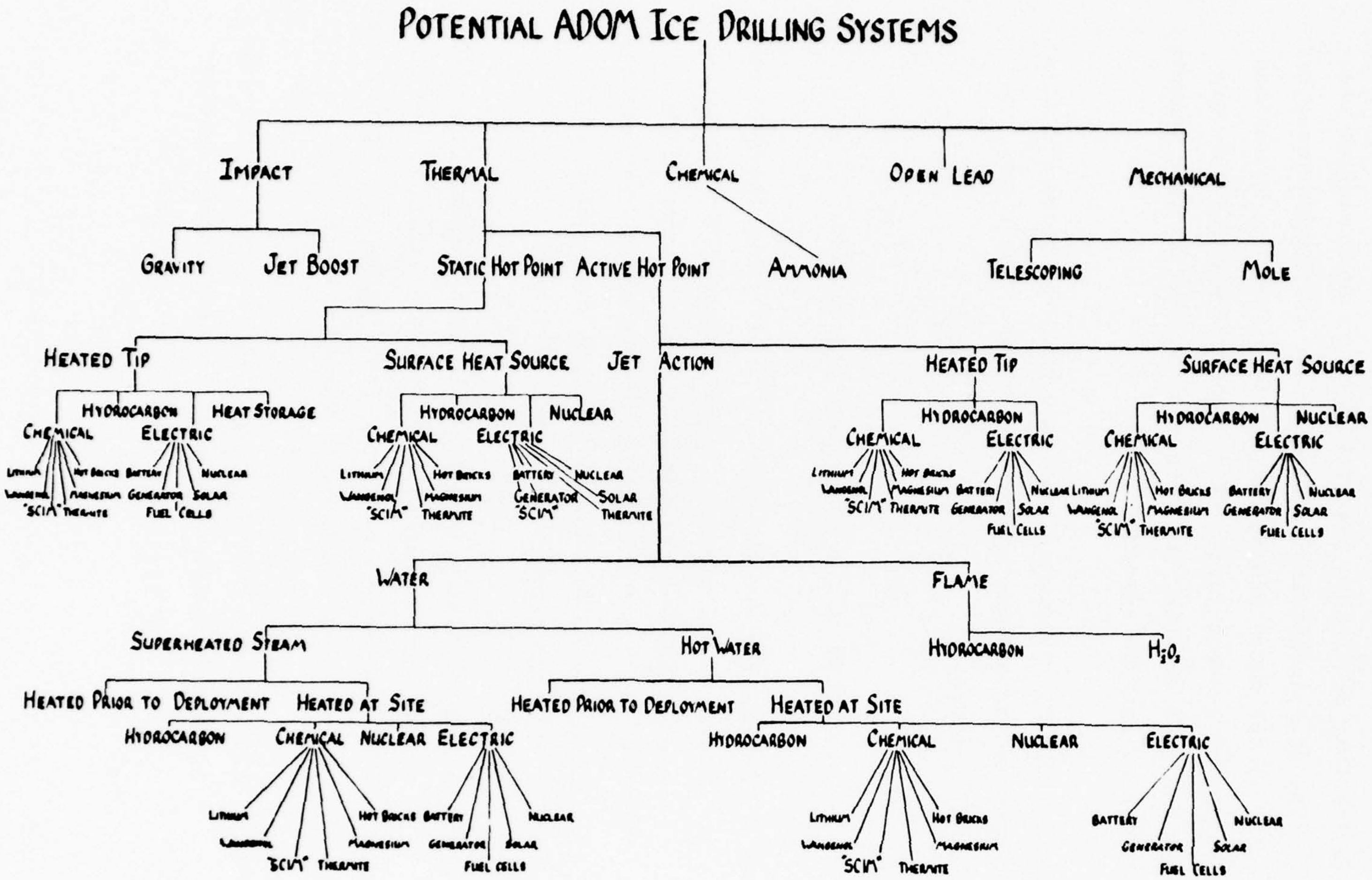

Figure 3-4. Potential ADOM Ice Drilling Systems

On close examination, it is seen that both systems have similar characteristics. The only substantial difference is the design parameter of the velocity of the water around the hot point heating source and the configuration of the hot point. Since the two systems are very similar, heat transfer computer modeling will be used to find answers relative to each of the two systems.

The chosen battery systems are examined below in terms of anticipated performance, advantages and problem areas. The topics are the design goal headings.

Development Risk:	Least risk of the group that was studied.
Reliability:	The battery systems seem initially to be the most reliable of all systems in that they are inherently simple, the only complexity being an on/off device which will allow thermostatic control of the hotpoint during times of thermal mismatch when a need exists to eliminate overheating problems.
Compatibility:	A battery system is compatible with the existing ADOM system components; in fact, it is possible to use any remaining energy after the drilling process is finished to power the remainder of the ADOM system.
Survivability:	The proposed battery system can be made structurally survivable under the specified 100 G impact loading due to its rugged construction and its lack of moving parts.
Size & Weight:	Initial calculations of energy density and hotpoint volume show very little need for concern in meeting

the constraints for packaging to be carried on aircraft. More work must be done relative to the actual interface and space requirements of other ADOM system components.

Environmental Impact: The battery system is an inherently "clean" system.

Energy Requirements: Theoretical analysis of energy requirements to drill a 15.2 cm (6 in.) hole in 15.2 m (50 ft) of ice dictate energy levels on the order of 1.27×10^8 Joules (120,000 Btu's). Considerations of actual energy density of lithium batteries indicate that within the Arctic ADOM package it may be possible to store upwards of 1.58×10^8 Joules (150,000 Btu's) with relative ease.

Complexity: The battery systems, after considering many alternatives, seem to be the least complex. This characteristic makes this type of system very attractive for automatic operation.

3.2.4 COMPUTER SIMULATION MODEL FOR A RECIRCULATING HOT WATER JET ICE DRILL. The computer simulation model for a recirculating hot water jet ice drill utilizes standard heat transfer relationships and an analytical technique employing finite-difference approximations. A control volume is established around the drill probe and surrounding ice. Standard heat transfer relationships are used to perform the energy balance calculations.

In developing the computer program, certain assumptions were made concerning the heat transfer relationships between the jet stream and the ice. Experiments were made to gain insight into these heat transfer relationships, thereby providing the data necessary to "calibrate" the computer model and more accurately predict the drill's performance under varying conditions.

3.3 CONCLUSIONS.

The following conclusions have been drawn from the past year's efforts:

a. It has been determined that a drill capable of passing through 15.2 meters (50 ft) of ice would penetrate 99 percent of the Arctic cover.

b. It has been determined that, depending on the systems employed, a design for a lesser depth, even to 10.7 meters, (35.1 ft) could prove cost effective.

c. Eighty seven basic approaches were examined for drilling through the ice. Based on decision rules that stressed reliability, and a likelihood for early reduction to practice, a system was selected that employed a battery-powered hot water jet and recirculated and reheated melt water for drilling.

d. A thermodynamic computer model of the proposed drill was created, and used to establish engineering parameters for the drill design. Resulting questions were raised about the thermal coefficients of the ice which will be actually encountered in Arctic ice with a high velocity scrubbing jet. The model confirmed earlier estimates that 35-45 kWh of energy is likely to be required for a hole 15.2 cm (6 in.) in diameter and 15.2 meters (50 ft) deep. An experiment with the proposed drill will be discussed below.

e. A plan for experimentally determining the thermal coefficients of ice was generated. Experiments are being conducted in co-operation with the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL).

f. A first attempt at Arctic ADOM packaging was completed. It shows that a cylinder 53.3 cm (21 in.) in diameter, 335.3 cm (132 in.) long, weighing in the vicinity of 657.6 kg (1450 lbs) will be sufficient. The experiences ahead may, indeed, modify these target dimensions substantially.

3.4 ADDITIONAL DEVELOPMENTS.

An experiment is presently in progress at the United States Army Cold Regions Research and Engineering Laboratory, Hanover, N.H. to verify the operation of a recirculating hot water jet ice drill. Initial testing has produced several holes approximately 15.2 cm (6 in.) in diameter and 61 cm (24 in.) deep. On 8 March 1979, using an improved model version of the thermal drill, a hole approximately 18.8 cm (7.4 in.) in diameter and 205.7 cm (81 in.) deep was successfully drilled. Energy input was approximately 30.9 kW with melt water recirculation flow rate of 2.84 x 10^{-3} m^3/s (45GPM). The drill was equipped with a 1.3 cm (0.5 in.) diameter nozzle. Drilling time was 17 minutes, which included a five minute interval when the heater was shut off after 2.3 minutes into the test. Subsequent drilling tests have achieved drilling rates greater than 17.34 cm (6.84 in.) per minute at energy inputs of approximately 30kW, using a 1.3 cm (0.5 in.) diameter nozzle and flow rates of approximately 2.84 x 10^{-3} m^3/s (45GPM). Figure 3-5 is a photograph of the first model drill probe, showing the nozzle end, recirculating intake, and water input and output lines. This model has subsequently been replaced with an improved version allowing drilling through 3.1 m (10 ft) of ice.

Initial results of the drilling tests indicate that extremely high heat transfer coefficients do indeed exist in the jet impingement area and that the drilling process is quite efficient as predicted by the computer model.

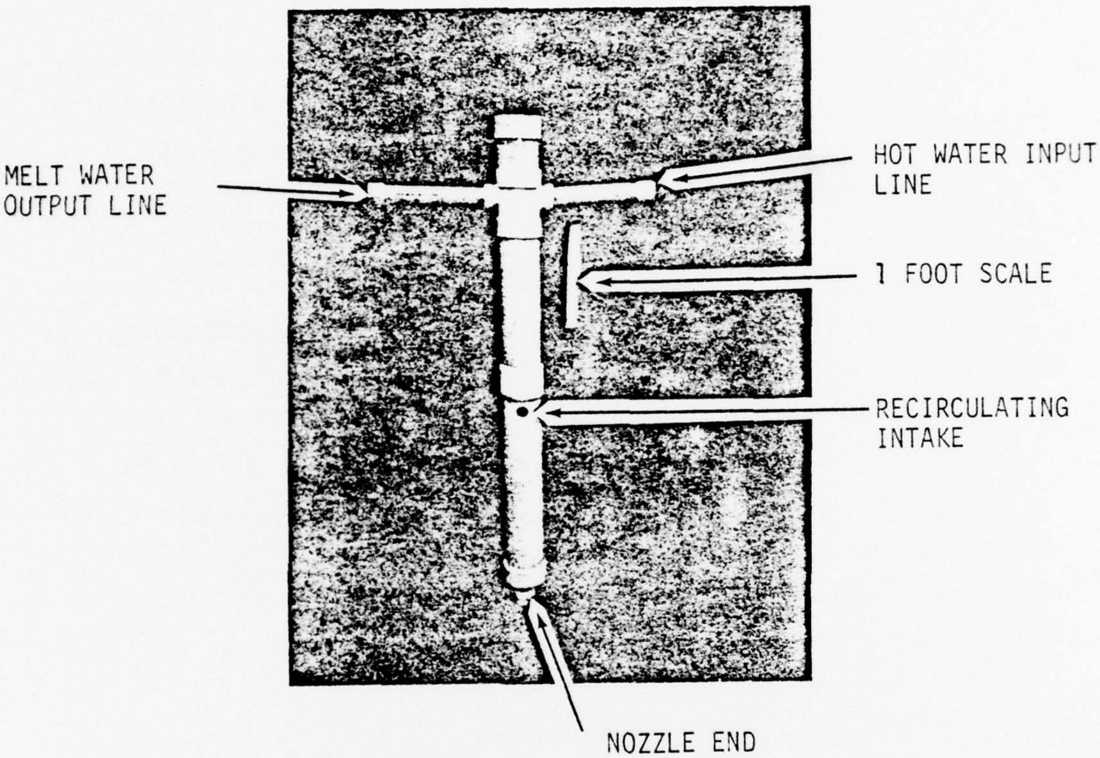

Figure 3-5. Model Drill Probe

SECTION IV

FUTURE ACTIONS

4.1 GENERAL.

This section describes the actions, further analysis and investigations necessary in the continuation of the ADOM technology development. The open ocean system and Arctic ocean system configurations are discussed below.

4.2 OPEN OCEAN SYSTEM.

The planned actions during 1979 are as follows:

a. Tests will be conducted on the various components of the ADOM to ensure proper operation and compatibility with the other components.

b. At-sea tests have been scheduled for 1979 to determine the horizontal holding capacity of the anchor, peak tensions experienced during lockup of the anchor, reliability of line payout, anchor module hydrodynamic stability during descent, and ability to set the subsurface buoy at 100 meters depth below the surface. Computer programs will be developed to provide analytical solutions to many of these problems. Particular emphasis is being placed upon the value of system impact forces on deployment and anchor lockup. The influence of current shear on the amount of mooring line payed out will be closely examined. A scheme to adjust the subsurface float to 100 meters will be analyzed and physically modeled.

c. In the electronics and sensor development, the lithium battery tests will be completed, a drift test of the sensor cable and sensors will be conducted, the array and processor configuration will be finalized, the telemetry system for use with the U.S. Air Force LES 8/9 satellites defined, and a moored test of the entire electronics package will be conducted.

d. Open ocean ADOMs will be fabricated and assembled in preparation for the aircraft drop of an open ocean ADOM in March 1980.

4.3 ARCTIC SYSTEM.

The planned actions during 1979 are as follows:

a. The concept validation model (CVM) design will be completed using a manually operated ice drill system. The actual drill probe will be designed to be manually operated, i.e., without its final electronic control system, but will be dimensionally identical to the proposed Arctic ADOM drilling system.

b. The CVM ice drill system will be fabricated and in-house testing and checkout performed.

c. A series of tests of the CVM will be performed at the U.S. Army Cold Regions Research and Engineering Laboratory in Hanover, New Hampshire, simulating an Arctic environment.

d. The design of the Advanced Development Model (ADM) of the ice ADOM will be completed. The ADM will be a complete automatically operated, self-contained ice drilling system.

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3. Morev, V.A. "Efficiency and Economics of Electrothermal Devices during Inland Ice Drilling", Soviet Antarctic Expedition Transaction, v 55, page 158-165, 1972.

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APPENDIX A

APPENDIX A

INFORMATION NECESSARY TO DETERMINE AIRCRAFT/STORE AND STORE/HANDLING-LOADING EQUIPMENT COMPATIBILITY

NAVAIR Instruction 3710.7A, Aircraft/store/suspension equipment compatibility, store/handling - loading equipment compatibility, and flight operating limitations for aircraft carrying stores, dated 1 November 1974, assigns responsibilities within the Navy for making key decisions prior to actual use of any aircraft in the inventory. Enclosure (2) of the instruction contains the complete collection of required analyses and test data. Extracts from enclosure (2) are presented below.

Analyses and test data required to determine aircraft/store/suspension equipment compatibility and store/handling-loading equipment compatibility and to establish safe operating limitations shall include, but not necessarily be limited to, the following:

a. Description of the store/suspension equipment

(1) Weight (empty and full if applicable)
(2) Physical dimensions (outline drawing to include dimensions):

(a) Lug spacing.
(b) Distance from front lug to nose, with each authorized spacing (if applicable).
(c) Body diameter.
(d) Fin(s) span, length (folded and deployed).
(e) Fin mounting position (with respect to lugs).
(f) Overall store length for each operational configuration (i.e., fuzes, fins, etc.).
(g) Location and identification of connectors; electrical, hydraulic, pneumatic, fuel and air; other required interfaces.

(3) Center of gravity location(s) (full, empty, and partial loadings, where applicable).

(4) Moments and products of inertia (pitch, yaw, and roll)

(5) Strong back/sway brace/cradle area dimensions and location

(6) Ejector piston(s) location and ejection characteristics for suspension equipment.

(7) Gun recoil forces and dispenser reaction loads

(8) Electrical connector(s)

(a) Type and location

(b) Pin assignment

(c) Power current and voltage levels

(d) Control current and voltage levels

(e) GSE test/checkout points/functions

(9) Store antenna location/orientation requirements

(10) Store seeker limits (including limit acceleration rates and normal load factors)

(11) Release sequence of multiple suspension equipment

(12) Store sensing device(s) of suspension equipment

(13) Store fuze type

(14) Arming wire routing

(15) For new suspension equipment, a list of the stores to be carried thereon.

(16) Pitch, roll, and yaw moment coefficients as a function of Mach No. and angle of attack and sideslip, with the reference center of gravity identified.

(17) Installed drag coefficients as a function of Mach No. for each carrying aircraft.

(18) For tow-targets, a description of the tow-target reel high-speed operating characteristics and variations of store weight and center gravity and tow forces as a function of line deployed/Mach No./target.

(19) Maximum permissible ejection force (ejection impulse curves).

b. Identification of the carrying aircraft

(1) Model designation

(2) Description of intended store/suspension equipment and location for take-off, landing, catapulting and arresting, including orientation of the store/suspension equipment with respect to the aircraft.

(3) Anticipated operations and maneuvers

(4) Planned operating speeds and altitudes

c. Estimated effects on aircraft performance characteristics

(1) Stall speed

(2) Take-off and landing distances

(3) Rate of climb

(4) Ceilings

(5) Range

(6) Radius

(7) Fuel flow

(8) Maximum speed

d. Design strength

(1) Strength envelopes for carriage, catapulting, and arresting

(2) Basis for strength envelope (i.e. MIL-A-8591 C, D, E, or other specification or document)

e. Substantiation of structural integrity

(1) Design analyses

(2) Flight-test data

(3) Shipboard-suitability data

(4) Take-off and landing test data

(5) Laboratory test data

f. Flutter characteristics

(1) Flutter analysis of the aircraft with store(s)

(2) Wind tunnel flutter test and data of the aircraft with store model

(3) Flutter flight test of the aircraft-with-store(s)

g. Aerodynamic characteristics

(1) Wind tunnel test data of store

(2) Wind tunnel test data of aircraft-with-store(s)

(3) Flight test data of aircraft with store to determine effects on stability and control, flying qualities, and performance. Stability and control data shall include the effects on the center of gravity limits stated in percent M.A.C., or in index units for aircraft using the index system.

(4) Store separation and employment/jettison characteristics

(5) Store separation and employment/jettison launch tests

h. For store/handling-loading equipment compatibility:

(1) Description of shipping container

(2) A description of the standard (or special) handling-loading equipments and techniques (shipboard and shorebase types of equipment), which are required to coexist with stores under operating conditions, while transported to, and during aircraft loading.

i. Anticipated development, production, and release-to-Fleet schedule.

j. In the case of adding an existing store to an existing aircraft, available information concerning aircraft previously carrying the store including:

(1) Model designation

(2) Description of store racks and locations

(3) Speeds and altitudes

(4) Aircraft flight envelope and maneuvers employed

k. Electromagnetic Compatibility - Description of the effect of the effects of anticipated electromagnetic environment on the compatibility of the aircraft and store, including electronic and explosive subsystems and components.

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This report documents the technological accomplishments in the Air Deployed Oceanographic Mooring (ADOM) program during 1978. Technology is being developed for deploying oceanographic sensors from an aircraft in two regions of the world's oceans: the open ocean and the polar seas. Two corresponding systems are being developed: an open ocean ADOM and an Arctic ADOM. Both systems are presently configured to measure temperature, conductivity, and pressure. The actions, further analysis, and investigations necessary in the continuation of the ADOM technology development are detailed.

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